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FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
MINISTRY OF EDUCATION

General Education Curriculum

Chemistry (Flow Chart, MLC & Syllabus)

9-12

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Introduction chemistry curriculum

Students need an understanding of chemistry to fully appreciate the complexity and interactions present in their world. Chemistry deals with the composition, properties, and transformation of substances. The study of chemistry should help the students to increase their analytical and perceptive capabilities and provide an opportunity to explore vocations in the field of chemistry. It also provides students with the knowledge and skills in chemistry and technology and enables them to solve problems and make decisions in everyday life based on scientific attitudes and noble values.

To achieve the above-mentioned purpose and to cope up with the current demands of chemical knowledge for technological, agricultural, and industrial development chemistry curriculum has to be updated all through the grade levels. The chemistry curriculum for grades 9 to 12 are then revised based on the new curriculum framework of Ethiopian schools taking into consideration the assessment made in March 2008 in selected secondary schools of the country, international experiences, and the current situations of our country. Feedback of the assessment made it clear that the secondary school curriculum has a problem of content overload, content difficulty inappropriate to the grade levels, giving less emphasis to active learning methods, limitations in integrating agriculture, and technology and unnecessary repetitions. This curriculum revision has intended to address these problems.

The revision also considered international experiences of the chemistry curriculum of different countries including India, Malaysia, Singapore, England, Ghana, and Uganda. The developed zero draft of the curriculum was also evaluated by both international and national reviewers. The comments and suggestions given by the national reviewers were very constructive and valuable to improve the quality of the developed curriculum. The international reviewers from Cambridge University has also contributed a lot to keeping standards by sharing their experiences and involving in the revision processes.

Consideration of the above-mentioned major points led to some restructuring of the units of grades 9 to 12. Some contents such as “measurements and units in chemistry” and “Solutions” are tools to learn chemistry and therefore moved from grade 11 and 12 (in the previous curriculum) to grade 9 and 10, respectively. On the other hands, contents such as intermolecular

forces and physical states of matter are moved from grade 9 to grade 11 considering content difficulty. In grade 9, the titles Chemical Symbols, Formulas, and Equations and chemical Reaction are collectively given under the unit Chemical Reaction and stoichiometry. Similarly, hydrocarbons and oxygen derivative hydrocarbons are given in grade 10 as Introduction to Organic Chemistry and the oxygen derivative hydrocarbons are taken to grade 12. In the unit of Electrolysis of grade 10, Electrolysis of aqueous solutions and their quantitative aspects are also moved to grade 12. To reduce the problems of content overload, the chemistry of only three selected metals (Al, Fe, and Cu) is treated in grade 10. Besides, some agricultural and industrial applications are integrated with the units. Some contents such as "introduction to Chemical Thermodynamics, Chemical Kinetics, Molecular Orbital Theory" are also move to freshman program in the University. Crosscutting issues such as environmental pollution global warming is included in grade 12.

Assessment is done through the continuous process; where, specific assessment techniques are selected to collect information about how well students are achieving the competencies. The assessment techniques used at any particular time depend on what facility with the knowledge, skill, or process the teacher wants the student to demonstrate. The appropriateness of the techniques, therefore, results in the content, the instructional strategies used, the level of development of the students, and what is to be assessed.

In general, the curriculum is developed in spiral way keeping the horizontal integration and the vertical progression of contents, encouraging practical activities, application of indigenous knowledge, use of locally available materials in learning chemistry, and develop the 21st century skills such as digital literacy.

Chemistry Flowchart for Grades 9 – 12

Thematic Area	Grade 9	Grade 10	Grade 11	Grade 12
Macroscopic world	**1. Introduction to Chemistry** • Definition and scope of Chemistry • Relationship between Chemistry and other natural sciences • Role played by Chemistry in production and society • Some common Chemical industries in Ethiopia	**1. Introduction to inorganic compounds** • **Oxides** - Types and properties - preparation of oxides • **Acids and bases** • The pH scale • Properties, preparation and uses of acids and bases • **Salts** - Naming and classification of salts -Preparation and uses of salts		
	2. Measurements and scientific methods in Chemistry • Measurements and Units in Chemistry • SI Units: Basic and Derived • Prefixes used in SI Units • Uncertainty in Measurement • Precision and Accuracy • Decimal Places • Significant Figures • Scientific Notation			

	• Chemistry as Experimental Science • Scientific Method • Experimental Skills in Chemistry Writing a Laboratory Report			
Microscopic World	**3. Structure of the atom** • Historical development of the atomic theories of matter • Fundamental Laws of Chemical Reactions - The Law of Conservation of Mass -The Law of Definite Proportions - The Law of Multiple Proportions • Atomic theory - Dalton's atomic theory - Dalton's atomic model • Discoveries of the Fundamental Subatomic Particles • discovery of the electron (J.J. Thomson's model) • Discovery of the Atomic Nucleus (Rutherford's model) • discovery of the neutron (Jams Chadwick's model) - Atomic number, mass number, atomic mass and	**2. Solutions** • Homogeneous and Heterogeneous Mixtures • Types of Solutions • The Solution Process • Solubility as an Equilibrium Process • Ways of Expressing Concentrations of Solutions • Preparation of Solutions • Solution Stoichiometry • Describing Reactions in Solution		

	isotopes - The Bohr's atomic model • Energy level and electric configuration			
Patterns in the Chemical World	**4. Periodic classification of the elements** • Historical development of periodic classification of the elements • Mendleev's periodic classification of the elements - Mendleev's periodic law - Periodicity • Modern periodic classification of the elements - Modern periodic law - Electronic configuration of the elements and the periodic Table (using main shells) - Periods and groups - The modern periodic table		**1. Atomic structure and Periodic properties of the elements** • Brief review of atomic structure of matter (Refer grade 9 unit 3) • Early experiments to characterize the atom - Electromagnetic Radiation (EMR) and Atomic Spectra - The Quantum Mechanical Model of the Atom - Electronic configurations and orbital diagrams - Electronic Configurations and The Periodic table of The Elements using sub-energy levels	
Chemical relationships	**5. Chemical Bonding**, • Chemical bonding		**2. Chemical bonding** • Brief review on the types of chemical bonding (Ionic, Covalent, and metallic	

	• Types of chemical bonding - Ionic bonding - Covalent bonding - Metallic bonding		bonding) (Refer grade 9 unit 6) • Molecular Geometry (VSEPR theory) • Intermolecular Forces in Covalent Compounds • Intermolecular forces and states of matter - Dipole-dipole forces - London dispersion forces - Van der wales - Hydrogen bonding • Chemical Bonding theories - Valence Bond Theory - Hybridization of atomic orbitals - Molecular Orbital Theory • Types of crystal **3. Physical states of matter** • Introduction to physical states of matter • The kinetic theory of matter -The gaseous state - The Kinetic Molecular Theory of Gases - The Gas Laws • The liquid state - Phase Changes in liquids - Energy Changes in Liquids • The solid state - Phase Changes in solids	

			- Energy Changes in Solids	
Chemical Reactions and Energy Changes		**3. Chemical reaction and stoichiometry** • Introduction to chemical reaction •. Types of chemical reactions -composition reactions -Decomposition reactions -single displacement reactions -Double displacement reactions • Chemical Equations - Writing Chemical Equation -Balancing Chemical Equation by inspection and LCM method • Oxidation-Reduction Reactions - Oxidation Number or Oxidation State - Oxidizing and Reducing Agents - Balancing redox - reactions using oxidation number change method Molecular and formula mass, the mole concept and chemical formula	**4. Chemical kinetics** • Introduction to Rate of Chemical Reaction - Pre-conditions for a Chemical Reaction to occur - Factors Affecting the Rates of Chemical Reaction **5. Chemical equilibrium** • Introduction • Reversible and Irreversible Reactions • Dynamic Chemical Equilibrium • Conditions for Attainment of Chemical Equilibrium • Factors affecting position of Chemical Equilibrium • Le Chatelier's Principle • Applications of Chemical Equilibrium to Industrial production	**1.Acid-Base equilibrium** • Acid-Base Concepts - Arrhenius concept - Bronsted-Lowrey concept - Lewis's concept • Acidity and basicity of solutions (pH and pOH) • Strong and weak acids and bases • Ionic Equilibria of Weak Acids and Bases • Common Ion Effect (Application of Le Chatelier's Principle) • Buffer Solutions • Hydrolysis of Salts • Acid-Base Indicators **2.Electrochemistry** • Electrolysis of Aqueous Solutions • Quantitative Aspects of Electrolysis • Voltaic (Galvanic) Cells and electrolytic cells • Industrial Application of Electrolysis **3.Industrial Chemistry** • Natural resources ✓ Renewable ✓ non-renewable

		-Molecular mass and formula mass -The mole concept -Percent composition -Chemical formulas: Determination of empirical and molecular formula • Stoichiometry - Laws of conservation mass (Brief revision) -The mole concepts - Molar Ratios in Balanced Chemical Equation -Mole -mole relationship - Mass–Mass Relationships - Volume-Volume Relationships - Mass–Volume Relationships - Limiting and Excess Reactants - Theoretical, Actual and Percentage Yields **4. Energy changes in chemical reactions** • Introduction • Exothermic and Endothermic Reactions		natural resources • Manufacturing of valuable products • Ammonia • Nitric acid • Sulphuric acid • Nitrogen based Fertilizer • Aluminum sulphate • Agrochemicals (pesticides and herbicides) • Sodium hydroxide • Sodium carbonate • Some Manufacturing industries in Ethiopia ✓ Glass production ✓ Ceramics production ✓ cement ✓ Soaps and Detergents ✓ Sugar ✓ Beverage industry ✓ Food processing and preservation ✓ Tannery

		• Electrical energy from chemical reactions - Electrical conductivity (electrolytes and nonelectrolytes) - Electrolysis - Electrochemical cells - Electrochemical cells in daily life **5. Metals and non-metals** • Introduction • General properties of metals • Occurrence, extraction and uses of some important metals • Alloys • General properties of nonmetals Occurrence, extraction and uses of some important nonmetals		
Compounds		**6. Hydrocarbons and their natural sources** • Introduction to organic compounds • Saturated Hydrocarbons: Alkanes and cycloalkanes	**6. Some important organic compounds** • Brief revision to hydrocarbons (Refer Unit 5 Grade 10) • Alcohols and Ethers • Aldehydes and Ketones • Carboxylic Acid and esters	**4.Polymers** • Introduction • Polymerization reactions • Synthetic Polymers • Natural Polymers

		• Unsaturated Hydrocarbons: Alkenes and Alkynes • Aromatic Hydrocarbons: Benzene • Natural Sources of Hydrocarbons	• Fats and Oils	
The Environment				**5. Introduction to Environmental Chemistry** • Introduction • Environmental pollution and methods to reduce pollution ✓ Air pollution (causes, effects mechanism to reduce) ✓ Water pollution (causes, effects and mechanism to reduce) ✓ Soil pollution (causes, effects and mechanism to reduce) • Global warming and climate change • Principle of green Chemistry and cleaner production

Minimum Learning Competencies

Chemistry, Grades 9 to 12

Minimum Learning Competencies (MLCs) of Chemistry for Grade 9 to 12

Area of Competency	Grade 9	Grade 10	Grade 11	Grade 12
1. Macroscopic world	• Define chemistry • Explain the scope of chemistry • Describe the relationships between chemistry and other natural sciences • Identify the importance of chemistry in their daily life • Identify some common chemicals and apparatuses used in chemistry Laboratories • List and describe some common chemical industries in Ethiopia • Describe the SI units & their prefixes; • Write the names & symbols of derived SI units; • Identify causes of uncertainty in measurement; • Explain systematic & random errors;	• Classify inorganic compounds in to oxides, acids, bases and salts • Define oxides and classify them in to acidic oxides, basic oxides, neutral oxides, Amphoteric oxides and peroxides • Give examples of acidic oxides, explain their properties and methods of preparation • Describe amphoteric oxides, give examples and explain their properties • Give examples of neutral oxides and explain their properties. • Define acids and bases and give commonly available examples from their surroundings • Classify acids and bases on the number of ionizable (replaceable) hydrogen ion (H^+) and based on the number of elements they are composed of.		

	• Define precision & accuracy • Analyses a given data in terms of precision & accuracy; • Define significant figures & determine the number of significant figures in a calculated result; • Use the scientific notation in writing very large or very small numbers; • Define scientific method, describe its major steps & use it in solving problems; • Demonstrate some experimental skills in chemistry & describe the procedures of writing laboratory report	• Explain the general properties of acids and bases • Distinguish between Strong and weak acids; concentrated and diluted acids • Distinguish between Strong and weak bases; concentrated and diluted bases • Use the necessary precautions while working with acids and bases • Define pH and pOH, • describe the pH scale and identify a given pH labeled solution as acidic, basic or neutral • Perform an activity to categorize some common substances as acid, base or neutral using indicators from locally available resources (e.g. flower extract) • Explain methods of preparing acids and bases and describe the uses of the three common laboratory acids and the three common laboratory bases • Conduct simple experiment to prepare acids and bases in the laboratory		

		• Define salts and give examples • Classify salts as acidic, basic, and normal salts • Explain properties of salts • Demonstrate methods of preparing salts • List some important salts and explain their uses • Describe the chemical tests for some salts (Sulfates, chlorides, nitrates, and carbonates) • Describe the importance of some salts (NaCl, $CaCO_3$ and $CaSO_4$) in daily life • Define fertilizers and describe their importance • Describe the functions of nitrogen, phosphorus and potassium for plant growth • List some common inorganic compounds that are used as pesticides		
II. Microscopic World	• Describe the historical development of atomic theories of matter • Describe the law of proportion and multiple proportion • State the law of conservation of mass, illustrate with examples	• Define the terms mixture, homogenous & heterogeneous mixtures, solute, solvent, solution; • Differentiate between homogeneous & heterogeneous mixtures; • Explain different types of solutions & give examples for		

	and demonstrate using simple experiment • Compare and contrast Dalton's Atomic with Modern Atomic Theories • Describe the discoveries of the Fundamental Subatomic Particles and the Atomic Nucleus • Describe the relative mass and the charge of sub-atomic particles • Identify location of fundamental sub-atomic particles using diagrams • Distinguish the relationships between atomic number, mass number, and atomic mass • Determine the number of electrons, protons and neutrons from the atomic number and mass number • Define isotopes and give examples of isotopes of hydrogen, chlorine and carbon • Explain main Energy levels, Valence electrons, and electron configuration • Show the arrangement of electrons in energy sublevels and write the electron configuration of	each; • Define heat of solution, solvation energy & hydration energy; • Explain the solution process • Explain formation of saturated & supersaturated solutions; • Define solubility & describe the factors that affect it; • Conduct an experiment to determine solubility of table salt & sugar; • State Henry's law & use it to calculate concentration of gaseous solute in a solution; • Define concentration of a solution, mass percentage of a solute in a solution, mole fraction , molarity , molality, equivalent mass, number of equivalents & normality; • Calculate the mass percentage & mole fraction of a solute in a solution • Prepare molar , normal & molal solutions of different substances; • Calculate molarity, normality & molality of a solution from a given information; • Explain dilution process & calculate the volume or concentration changes during		

	the first 20 elements in main energy levels	dilution of solution; • Do calculations involving solutions to determine the number of moles, masses or volumes of reactants and products in ionic reactions; • Analyze ionic reactions and write net ionic equations; • List the important properties of solvents that are affected by the formation of a solution;		
III. Patterns in the Chemical World	• Describe the historical development of periodic classification of elements • Explain periodicity and state the Mendeleev's periodic law • Discuss the contribution and short comings of Mendeleev's periodic classification • State the modern periodic law • Define the period and the group • Correlate the electronic configuration of the elements and their arrangements in the periodic table (using main		• Discuss the historical development of atomic nature of substance • Evaluate postulates of Dalton's & modern atomic theories • Show diagrammatic representation of the discovery of electron & analyze the properties of cathode rays • Distinguish the terms : radioactivity, radioactive decay & radioisotope • Differentiate the common types of radioactive emission • Show the alpha scattering experiment in diagram • Describe makeup of the	

	shell) • Tell the number of elements in each period and write the name of the main group elements in the periodic table • Classify elements as representative, transition & inner transition • Describe the major trends in periodic table (atomic size, ionization energy, electron affinity and electronegativity		nucleus • Define atomic mass & isotope • Differentiate atomic number & mass number; • Calculate the number of protons, electrons & the number of neutrons from the given atomic number & mass number of an element • Evaluate the relative atomic mass of naturally occurring isotopic elements • Organize electromagnetic radiation in terms of wavelength, frequency & calculate the wavelength & frequency of the electromagnetic radiation • Check that light has both wave & particle nature & the emission spectra of atoms consist of series of lines • Evaluate Bohr's assumption of energy of electron in hydrogen atom • Calculate the radius of electron orbit, the electron velocity & the	

			energy of an electron using Bohr model • Discuss that atoms emit or absorb energy when electrons undergo transition from one energy level to another • Analyze the spectrum of hydrogen to demonstrates the quantized nature of the energy of its electron • Evaluate the short coming of Bohr's theory • State Hinesburg's uncertainty principle & describe the significance of electron probability distribution • Differentiate the quantum numbers n, l, ml & ms • Write all possible sets of quantum numbers of electrons in an atom • Draw the shapes of orbitals of s, p, d, and f • Discuss Aufbau principle, Pauli exclusion principle & Hund's rule • Write ground state electron configuration of main group and transition elements	

			• Describe atomic size, nuclear charge, metallic and nonmetallic character of elements across the period and down a group of the modern periodic table • Explain the general trends in atomic radius, ionization energy, electron affinity, electro-negativity & metallic character of elements within a period & a group of the periodic table • Discuss the importance of periodic classification of elements in the study of properties of substances	
Chemical relationships	• Define chemical bonding and explain why atoms form chemical bonds with other atoms • Relate the concept of chemical bonding with atomic structure learned in chapter 3 grade 9 •Define ionic bond and describe its formation • Explain the general properties of ionic	•	• Define chemical bonding (Refer to grade 9 chapter 5) • Discuss the reason why atom from chemical bonds • Explain ionic bonding and its formation • Give examples of ionic compounds & describe their properties • Define lattice energy	•

	compounds •Define covalent bond, and describe its formation • explain the general properties of covalent compounds • state the octet rule • Draw the Lewis electrons dot formula of simple covalent and ionic compounds •Make models of molecules to show single, double and triple bonds using balls and sticks of locally available materials •Give examples of locally available ionic and covalent compounds and explain their properties •Elucidate polarity of covalent molecules • Distinguish between polar and nonpolar molecules • Define metallic bonding • Describe thermal and electrical conductivity of metal in relation to metallic bond		• Calculate the lattice energy of ionic crystals from a given data using the methods of Born-Haber cycle • Describe ionic bonding using Lewis's electron dot symbols • Discuss the limitation of Octet rule • Define covalent bonding & explain the formation of covalent bonding • Give examples of covalent molecules & describe their properties • Draw Lewis structures of some covalent molecules • Define resonance & draw resonance structures of some covalent molecules & polyatomic ions • Discuss the exceptions to the Octet rule in covalent bonding • Illustrate the formation of coordinate covalent bonding using examples • Differentiate between	

			polar & non-polar covalent molecules • Describe the properties of covalent molecules • Define intermolecular force & list the different types of intermolecular forces • Explain dipole-dipole interaction & give examples of them • Define hydrogen bonding & explain the effects of it on the properties of substances • Explain dispersion forces & give examples of them • Define metallic bonding & explain the properties of metals related to the concept of bonding • Explain the VBT • Distinguish between the Lewis model & valence bond model • Discuss the overlapping of orbital in covalent bond formation • Explain hybridization & show its process	

			involved in some covalent molecules • Draw hybridization diagram for the formation sp, sp^2 ,sp^3, sp^3d, sp^3d^2 hybrids • Discuss the hybridization involved in compounds containing multiple bonds • Describe the Valence Shell Electron Pair Repulsion (VSEPR) theory • Differentiate the bonding pairs & non-bonding pairs of electrons • Describe how electron pair arrangement of molecules can be predicted from the number of electron pairs • Explain the term dipole moment with the help of a diagram • Analyze the geometrical shapes of some simple molecules on the basis of hybridization & the nature of electron pairs • Explain the VSEPR	

			theory is used to explain the molecular parameters like bond angle & polarity of the molecule • Construct models to represent shapes of some simple molecules • explain molecular orbital theory • describe molecular orbital-using atomic orbitals • describe bonding and anti-bonding molecular orbitals • draw molecular orbital energy level diagrams for homonuclear diatomic molecules • write the electron configuration of simple molecules using the molecular orbital model • define bond order and determine the bond order of some simple molecules and molecule-ions • determine the stability of a molecule or an ion using its bond order; and predict magnetic	

			properties of molecules • Define crystal • Name the four types of crystalline solids and give examples. • Mention the type of attractive forces that exist within each type of crystalline solids • Describe the properties of each type of crystalline solids Build a model of sodium chloride crystal structure • Discuss the states of matter • Analyze the effects of intermolecular forces on the physical state of matter; • Explain the assumptions of kinetic molecular theory of gases; • Describe the properties of gases using kinetic molecular theory; • Describe the behavior of gases by using the variables *V*	

			(volume), *T* (Temperature) *P* (pressure) and *n* (number of moles); • State Boyle's law; • Perform an activity to illustrates Boyle's law by changing the volume and pressure of gases; • Apply Boyle's law in solving problems; • state Charles' law; • Perform an activity to illustrate Charles' law by changing the volume and temperature of gases; • Apply Charles' law in solving problems; • State Gay Lussac's law: • Derive combined gas law equation from Boyle's law and Charles' law; • Use the combined gas law to calculate changes in volume, pressure or temperature; • Define an ideal gas; •Explain Avogadro's	

			law • Derive an ideal gas equation from Boyle's law, Charles' law and Avogadro's law; • Compare the nature of real gases with ideal gases; • Solve problems related to ideal gas equation; • Define diffusion; • State Graham's law of diffusion; • Carry out an activity to compare the rate of diffusion of two different gases; • Apply Graham's law of diffusion in solving problems. • Describe phase changes • Discuss the • Explain the terms: evaporation, boiling condensation, vapour pressure, boiling point, molar heat of vaporization and molar heat of condensation. • Explain the terms melting, fusion, sublimation, melting point, freezing point,	

			molar heat of fusion and molar heat of solidification.	
Chemical Reactions and Energy Changes		• Define Chemical reaction and give examples • Identify the four types of chemical reactions and give examples • Represent chemical change using chemical equation • Balance chemical equations using inspection method • Apply the Least Common Multiple (LCM) methods to balance chemical equations • Define redox reaction • Describe oxidation and reduction in terms of electron transfer and give examples • Define oxidation number • State the rules to determine oxidation number • Determine the oxidation number of an element in a given formula • Describe oxidizing and reducing agents • Balancing redox reaction using oxidation number change method • Analyze a given redox reaction by specifying the substance reduced, the	• Define a reaction rate • Demonstrate a reaction rate using graphs • Perform an experiment to determine the relative rate of reactions • List factors affecting rate of chemical reaction • Explain how collision, activation energy and proper orientation of reactants are precondition for a chemical reaction to occur • Discuss the effect of changes in temperature, concentration or pressure and surface area on the rate of a chemical reaction • Explain the effect of catalysts on the rate of chemical reaction • Perform an activity on how temperature, concentration, pressure, and catalyst affect the rate of chemical reaction	• State acid & base by Arrhenius, Bronsted-Lowry & Lewis concepts & give examples of each; • State the drawback of Arrhenius acid /base • Identify the acid-base conjugate pairs from the given reaction; • Explain what is meant by amphiprotic species • Describe the ionization of water and derive the expression of ion product for water, Kw • Explain the effect of temperature on Kw • Define pH and pOH • Describe the relationship between pH and pOH • Write an expression for the percent ionization of weak acids or weak base • Write the expression for the acid dissociation constant, Ka; • Calculate Ka for an acid from the concentration of a given solution and its pH; • Write the expression for

		substance oxidized, the oxidizing agent and the reducing agent • Distinguish between redox and non-redox reaction • Solve molecular mass and formula mass problems based on the given chemical formula of compounds • State the mole concept and describe using example • Deduce percentage composition from formula mass/molecular mass of a compound • State empirical formula and molecular formula • Solve molecular formula problems based on the given empirical formula • Explain the use of the mole concept for solving stoichiometry problems • State the law of conservation of mass • Deduce mole ratios from balanced chemical equations • Solve mass-mass problems based on the given chemical equations	• Explain reversible & irreversible reactions • Define dynamic equilibrium, discuss how chemical equilibrium is established & explain its characteristics • State the law of mass action • Define equilibrium constant, write its expression involving concentration for chemical reactions & calculate it • Write the equilibrium constant expression involving partial pressure for chemical reactions & calculate it • Show relationship between Kc & Kp • Distinguish between homogeneous & heterogeneous equilibrium reaction • Define reaction quotient & use equilibrium quotient to predict the direction of the reaction & position of equilibrium	the base dissociation constant, K_b • Calculate K_b for a base from the concentration of the basic solution and its pOH. • Define common ion effect; • Explain the importance of common ion effect; • Define a buffer solution; • Explain the action of buffer solution and it's importance in chemical processes • Calculate the pH of a given buffer solution • Define hydrolysis; • Explain why a salt of weak acid and strong base gives a basic solution • Explain why a salt of strong acid and weak base gives an acidic solution • Explain why salts of weak acids and weak bases give acidic, basic or neutral solution • Describe acid-base indicators and give examples • Suggest suitable indicator for a given acid-base titration

		• State Avogadro's principle • Solve Volume-Volume and mass-volume problems based on the given chemical Equations • Deduce excess and limiting reactant in a reaction • Calculate the theoretical and percentage yields of a chemical reaction • Explain energy changes in chemical reactions • Define endothermic and exothermic reactions • Describe endothermic and exothermic reactions • Demonstrate endothermic and exothermic reactions using diagrams • Conduct simple experiment to demonstrate exothermic and endothermic reactions • Explain the importance of chemical changes in the production of new	• Calculate the equilibrium concentrations of a given initial concentrations • List factors that affect chemical equilibrium • Apply Le-chatlier principle to explain the effect of changes in temperature, pressure, concentration & presence of catalyst of a reaction on chemical equilibrium • Describe the applications of chemical equilibrium in chemical industries	• Calculate the normality of a given acidic or basic solution • Define acid-base titration • Define end point • Define equivalence point • Distinguish between end point and equivalent point; • Discuss the different types of titration curves • Define redox reactions, oxidation and reduction • Identify the species that are oxidized & reduced in a given redox reaction • Define electrode • Distinguish between molten electrolytes and aqueous electrolytes • Draw and label an electrolytic cell • Define preferential discharge & explain factors that affect it • Describe the reactivity of a metal using its position in the activity series • Describe the effect of nature of the ions, concentration of the ions,

		substances and energy • Define electrochemistry • Explain electrical conductivity • Differentiate between metallic conduction and electrolytic conduction • Define the term electrolysis • Distinguish between strong and weak electrolytes • Perform simple experiments to test conductivity of aqueous solution of substances • Describe anode, cathode, electrolyte, anion, and cation • Use labelled diagram to illustrate electrolytic cell • Define the terms half reaction and cell reaction • Write the oxidation half reaction, reduction half reaction and cell reaction for electrolysis of molten or fused electrolytes • Describe the importance of electrochemical cells in daily life (Votic cell and car battery) • Mention general properties of		types of the electrodes on the electrolysis of aqueous solutions of electrolytes • State Faraday's first & second law of electrolysis and write mathematical expression of them • Do calculations related to Faraday's first and second law of electrolysis • Define voltaic cell, salt bridge, electrode potential and cell potential • Draw, label and construct Zn-Cu voltaic cell • Measure the cell potential of Zn-Cu cell using voltmeter • Explain how standard electrode potential is measured and calculate cell potential • Decide whether a given redox reaction is spontaneous or not • Explain the effect of concentration on cell potential • Mention different types of voltaic cells and give examples of each • Distinguish between primary and secondary

		metals • Describe the forms of occurrence of some metals • List common compounds of Na, K, Mg, Ca, Al, Fe, Cu, & Ta and common uses of each metal • Define alloys and give bronze, brass, solder and steel as examples, • Describe some of the common properties of alloys & explain their uses • Mention general properties of Non-metals and uses • Explain the occurrence and uses of carbon, nitrogen phosphorus, Oxygen & Sulfur • Describe some common uses of compounds of nonmetals such as CO_2, Na_2CO_3, NH_3, HNO_3,H_3PO_4, $Ca_3(PO_4)_2$, SO_2 & H_2SO_4 • Define metallurgy & explain the major steps in metallurgical processes • Describe the chemical properties and extraction methods of aluminum, iron and copper • Describe the chemical properties and industrial production of nitrogen, phosphorus, sulfur and		cells • Identify the cathode, anode and electrolyte of a given voltaic cell • Compare and contrast electrolyte and voltaic cells • Explain metallic corrosion in terms of redox reaction , its negative effects and different methods of prevention • Discuss industrial applications of Electrochemistry • List natural resources • Classify natural resources as renewable and non-renewable • Describe the process of manufacturing of valuable products like Ammonia, sulphuric acid, sodium hydroxide, sodium carbonate and nitric acid • Outline the production steps valuable products like

		chlorine		Ammonia, sulphuric acid, sodium hydroxide, sodium carbonate and nitric acid • Discuss the uses of organic compounds in the manufacture of industrial products like beverages, pharmaceuticals, fuels, soaps and detergents and dry cleaning agents • Discuss local production of beverages (Tella, Teje, Areki, etc) and the importance of some ingredients (e.g. Gesho (Hope), Bekele(Malt), etc) in their production • Discuss the uses of organic compounds in the manufacture of agricultural products like pesticides, herbicides and nitrogen fertilizer • Produce pesticides from locally available materials • Mention the important steps in the production of glass, cement, sugar, sulfuric acid, aluminum sulphate, nitric acid,

				ammonia, and tanneries and agrochemicals (pesticides and herbicides) • Apply indigenous knowledge for preparation and use of nitrogen based fertilizer and pesticides • Describe different methods of food processing and preservation • Discuss and describe how alcoholic beverages are produced • Compile and Present a report in a class after collecting information from the community about local alcoholic beverage preparation • List and describe the process how soaps and detergents are produced • Students perform experiments in laboratory to prepare soap

				• Compile and Present a report in a class after visiting a nearby cottage industry of soap
Compounds		• Describe the historical development of organic chemistry • Classify organic compounds based on their functional group • Describe homologous series and its characteristic features • Define terms hydrocarbons, structural formula, condensed structural formula • Write the general formulas for Alkanes and cycloalkanes • Describe the physical and chemical properties of alkanes and cycloalkane • Write the molecular formula, condensed structural formula and names of the first ten members of alkanes and cycloalkanes • Give the IUPAC names for some straight, branched and ring chain alkanes • Write the possible structural isomers of the alkanes C_4H_{10}, C_5H_{12}, C_6H_{14} and C_7H_{16} • Write the general formulas for Alkenes • Describe the physical and	• Describe some important hydrocarbons • Classify alcohols based on the number of hydroxyl (OH) groups • Distinguish primary, secondary and tertiary alcohols • Write the general formula of monohydric alcohols and give some examples from each of them • Write the molecular formulas and names of the first six members of monohydric alcohols • Give the IUPAC names for given alcohols • Describe the physical properties of alcohols • Explain the industrial and laboratory preparation of ethanol • Explain the general methods of preparation of alcohols	• Define monomer and polymer • Classify polymers into synthetic and natural polymers give examples for each • Explain polymerization and mention the types of polymerizations • Explain how addition & condensation polymerization take place • Give examples of addition polymers and tell their monomers • Give examples of condensation polymers and tell their monomers • Explain the common uses of addition & condensation polymers • Describe thermoplastics and thermosetting polymers& give examples of each • Describe natural rubber and tell its monomers • Explain vulcanization

		chemical properties of alkenes • Write the molecular formula, condensed structural formula and names of the first ten members of alkenes • Give the IUPAC names for some straight, branched and ring chain alkenes • Write the possible structural isomers of the alkenes C_4H8, C_5H_{10}, C_6H_{12} and C_7H_{14} • Write cis-trans isomers for the given alkenes • Write the general formulas for Alkynes •Describe the physical and chemical properties of alkynes • Write the molecular formula, condensed structural formula and names of the first ten members of alkynes • Give the IUPAC names for some straight and branched chain alkynes • Write the possible structural isomers of the alkynes C_4H_6, C_5H8, $C_6H_{10\ and}\ C_7H_{12}$ • Explain why alkenes and alkynes undergo addition reaction but not substitution reaction • Describe the laboratory and	• Perform an activity of preparing locally distilled alcohol (Katikalla) • Explain the chemical reactions of alcohols such as oxidation, reaction with active metals, esterification and dehydration • Write the molecular formulas and names of the first six members of ethers • Give the IUPAC names for given ethers • Describe the physical properties of ethers • Explain the general methods of preparation of ethers • Explain the use of ethers such as solvent in organic reactions • Write the general structural formulas of aldehydes and Ketones • Give the structures and names of common members each group • Describe the physical properties of aldehydes	• Explain the use of natural rubber • Give examples of synthetic rubbers & explain their uses • Compare and contrast synthetic and natural rubber

		industrial preparation of methane, ethane and ethyne • Perform a project on the production of biogas from cow dung • Define aromatic hydrocarbons • Distinguish aromatic compounds from other hydrocarbons • Draw and explain the structure of benzene • Describe the main physical properties and chemical reactions of benzene • Perform simple chemical tests to identify alkanes, alkenes/alkynes, and aromatic compounds • List the natural sources of hydrocarbons and discuss how they are formed	and ketones • Explain the general methods of preparation of aldehydes and ketones • Explain the chemical reactions of aldehydes and ketones such as addition, oxidation and reduction • Write the general formula of saturated monocarboxylic acid • Write the molecular formulas and names of the first six members of saturated monocarboxylic acids & give their structural formulas • Give examples for monocarboxylic, dicarboxylic and tricarboxylic acids & name some branched carboxylic acids • Give some examples of carboxylic acids from locally available resources • Explain the general methods of preparation	

			of saturated monocarboxylic acids & the industrial and laboratory preparation of acetic acid • Conduct an experiment to prepare acetic acid in the laboratory • Explain why "Tella" or "Tej" turns sour • Describe physical properties and chemical reactions of saturated monocarboxylic acids • Name and write structural formulas of some fatty acids • Give the general formulas and naming system for derivatives of carboxylic acids such as esters, amides, acid halides and anhydrides • List common local sources of esters (e.g. Pineapple, banana) • Write the general formulas of esters and the molecular formulas & names of the first six members of esters • Explain the method of	

			preparation of esters • Describe physical properties and chemical reactions of esters • Define fats and oil • List some local sources of fat and oils • Write the general formula of fats and oil and the structures for some common triglycerides • Describe physical properties of fats and oil • Explain rancidity and hardening of oil • Describe some plants that have medicinal value in your local area	
The Environment				• Define Environmental Chemistry and concepts related to it • Describe components of the environment • Explain environmental pollution and mechanism to reduce pollution • Discuss air water and soil pollution • Describe the cause and effects air, water and soil pollution

				• Describe the methods to reduce air, water and soil pollution
				• Describe pollutants of the environment
				  ○ Heavy metals
				  ○ Organic dyes
				  ○ Pesticides and herbicides
				  ○ Radioactive materials e.t.c
				• Explain and describe Greenhouse effect and greenhouse gases.
				• Discuss global warming and climate change
				• Apply the principle of green chemistry and cleaner production while doing experiments

Chemistry Syllabus

For Grade 9

General Objectives of Grade 9 Chemistry

To Develop Understanding and Acquire knowledge of:

- The meaning and scope of chemistry
- Measurements in chemistry and scientific methods
- Dalton's atomic theory and modern atomic theory,
- Discoveries of the sub-atomic particles,
- The relationship between the sub-atomic particles and the atomic numbers, mass numbers, atomic masses and isotopes,
- Development of the atomic models and arrangement of the electrons in the atoms,
- Periodic classification of the elements and its importance in studying chemistry,
- The major types of chemical bonding

To Develop Skills and Abilities of:

- Apply scientific methods in solving problems;
- Develop measurement skill in chemistry
- Demonstrate an understanding of experimental skills in chemistry;
- Demonstrate a knowledge of laboratory procedures, data collections, interpretations, and write a report using computer
- Develop skills of classification from the observed patterns

To Develop the Habit and Attitude of:

- Appreciating that all substances are the results of chemical combination of the atoms
- Realizing that properties of substances are attributed to their atomic structures,
- Appreciating problem solving
- Develop personality characteristics such as neatness, exactness, diligence, responsibility and carefulness.

Unit 1: Introduction to Chemistry (16 periods)

Unit outcomes: Students will be able to:

- Define chemistry and describe its' scope
- Explain the relationships between chemistry and other natural sciences,
- Discuss the application of chemistry in production,
- List down some common chemical industries in Ethiopia
- Describe scientific enquiry skills along this unit observing, communicating, asking questions and making generalizations

Competencies	*Contents*	*Suggested activities*	*Assessment*
Students will be able to: • Define chemistry	***1. Chemistry and its importance*** 1.1 Definition and scope of chemistry *(4 period)* • Definition of chemistry	Students should be asked to discuss in group what they think chemistry is. Write terms on their note book like: • Nature • Forms of nature • Matter and non-matter • Science • Branches of Science • Study of nature From these terms extract a simple definition of chemistry in terms of studying the properties or reactions of materials when treated in different ways.	• Observe discussions and give summary

• Explain the scope of chemistry	• Scope of chemistry	Students should be asked what pictures the word 'chemistry' conjures' in their minds. They are likely to suggest things like: • Burning chemicals like acids • Bad smells • Explosions • Bottles of different coloured liquids • Pieces of apparatus • People in laboratory coats wearing safety glasses Students should identify that chemistry is all of these things. It is the study of substances by scientists, using a range of specialised equipment and apparatus. Chemistry is about taking measurements and making observations, and using them to come to conclusions. Chemistry is about looking for patterns in the way substances behave.	Observe the students reply and give feedback
• Discuss the relationship of chemistry with physics, biology and geology	1.2 Relationship between chemistry and other natural sciences *(4 period)*	Students should be asked to investigate the relationship between chemistry and other branches of natural sciences including biology, geology and physics. Students could be asked to write one sentence about each natural science saying exactly what areas or aspects of nature are studied e.g. • Biology – study of living things • Chemistry – study of the chemical properties and reactions of substances • Geology – study of the earth and how it was formed • Physics – study of the nature and interactions of matter and energy Students should be requested to identify the regions of overlap between the disciplines e.g. • Chemical reactions that take place in living things combine chemistry	Check what students write and give feedback Summarize the relationship between chemistry and other natural sciences

		and biology • Study on the composition of minerals involve chemistry and geology Students could be asked to identify other topics where the different scientific areas overlap.	
• Describe the application of chemistry in the field of agriculture, medicine, food production and building construction.	1.3 Role played by chemistry in production and society *(4 period)*	Students should be asked to write down five examples of materials from everyday life which were developed as a result of the expertise of chemists. For example they may choose: • House utensils like plates, forks, glasses, kettles • Drugs which can be bought from the pharmacy • Fuels used to power motor vehicles • Fertilizers used by farmers to increase crop yields • Cosmetics used to care for the skin • Building materials used in construction Let the teacher use the students' ideas to construct a large spider diagram showing the many different fields in which chemistry plays an important role.	Check students response and give feedback Summarize the applications of chemistry in daily life
• Name some common chemical industries in Ethiopia and their products	1.4 Some common chemical industries in Ethiopia *(4 period)*	Students should be able to name some of the common chemical industries in Ethiopia. These will include: • Cement (Mugher, Diredawa, Mesobo, Derba Midroc, Dangote) • Sugar (Metehara, Wonji, Finchaa, Omo kuraz) • Soap (Repi, Adama, Gullele, Etab,) • Paper and pulp (Wonji) • Pharmaceuticals (Addis pharm., Adigrat) • Sulfuric Acid and Aluminum sulfate (Awash Melkassa) • Caustic soda (Zeway) • Soda ash (Bulbula) • Tyre (Horizon Addis tyre)	Listen students response and give feedback
• Visit a local chemical industry		Students could be asked to discuss in group to find out about local chemical industries and prepare a three-minute presentation for the class. Emphasis	Listen students presentation and give

and present it to the class in group.		should be placed on raw materials and the finished products.	feedback

Unit 2: Measurements and scientific methods in Chemistry *(25 periods)*

Unit outcomes: Students will be able to:

- Use proper SI units;
- Identify the causes of uncertainty in measurement;
- Express the result of any calculation involving experimental data to the appropriate number of decimal places or significant figures;
- Apply scientific methods in solving problems;
- Demonstrate an understanding of experimental skills in chemistry;
- Demonstrate a knowledge of basic laboratory apparatuses and safety rules;
- Describe scientific enquiry skills along this unit: observing, inferring, predicting, comparing & contrasting, communicating, analyzing, classifying, applying, theorizing, measuring, asking question, developing hypothesis, designing experiment, interpreting data, drawing conclusion, making generalizations and problem solving.

Competencies	Contents	Suggested Activities	Assessment
Students will be able to:	**2. Measurements and scientific methods in Chemistry**		
• List and describe the seven SI units and their prefixes • Write the names and symbols of derived SI units • Use the factor label method for solving problems and making conversion of SI units.	**2.1 Measurements and units in Chemistry** *(15 periods)* • SI units (The International system of units) - Basic SI units - Derived SI units • Common prefixes used in SI units	Students should be conscious that SI units are used by scientists including chemists throughout the world. Students could discuss in group why having a common group of units is an advantage e.g. what is the problem with measuring pressure in Pascal, bars, pounds force per square inch and millimetres of mercury? Students should tell the total number of basic SI units and describe those are relevant to chemistry Students should realize that other units are derived from the SI units. They should discuss and give the derived units relevant to chemistry Students should be asked to tell that the commonly used unit in measuring temperature, pressure, volume, mass, density, are the SI or derived SI units. Students should understand that it is impractical to use the same unit for expressing all values for a particular quantity. Students could discuss why it would be difficult to express the amounts of chemicals used in industrial quantities and the amounts of chemicals present in pharmaceutical preparations both in kg. From	Observe group discussion and give feedback Summarize the importance of using common units, and the difference between SI and derived units Observe students discussion and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Describe uncertainty of measurement • Identify the digits that are certain and the ones that are uncertain given a number representing measurement • Identify causes of uncertainty in measurement • Define precision and accuracy • Estimate the precision possible for any instrument they use in the laboratory • Explain systematic and random errors • Analyse given data in terms of precision and accuracy	• Uncertainty in measurements • Precision and accuracy	this discussion the students should develop the idea of using prefixes to express multiples of units: • mega (M) = 10^6 • kilo (k) =10^3 • milli (m) = 10^{-3} • micro (μ) = 10^{-6} Students should be made aware of the appropriate use of upper and lower case e.g. possible confusion between mega (M) and milli (m). Students could practice conversion between units e.g. between micrograms, milligrams, grams, kilograms, mega grams (tonnes). Students should identify, even with careful measurement, there is a limit to the degree of accuracy of an instrument. For example, with skill and practice a student may read a burette to the nearest 0.05 cm^3 but no more accurately than that. Students should be asked to reflect their expectations of the accuracy of the instruments they use. Students should list the potential sources of errors in taking readings e.g. measuring the temperature of a solution by inserting a thermometer but waiting sufficient time for the thermometer to attain the same temperature as the solution. Students should be able to identify an anomalous reading in a set	Check on a sample of exercises Provide feedback Check on a sample of exercises Provide feedback

Competencies	Contents	Suggested Activities	Assessment
• Define decimal places • Determine the number of decimal places in a calculated result	• Decimal places	of data and suggest a reason for it. Students should be asked to show the limitations of accuracy in taking measurements. For example, if the mass of a chemical is given as 2.5 g the actual mass may be anything from 2.450 g to 2.549 g. Students should be able to express the uncertainty in any measurement and the limit of accuracy of a calculation using this measurement. Students should be able to round up numbers either to a particular number of decimal places or significant figures. The process for this is similar. Students should indicate that: • to express a value to the n^{th} decimal place they look at the value of the $n+1^{th}$ digit • if the $n+1^{th}$ digit is 5 or more they round up the n^{th} digit • if the $n+1^{th}$ digit is 4 or less they leave the n^{th} digit unchanged Students should be talked through some examples and then attempt some examples for themselves e.g. • express 24.546 g to 1 decimal place • the second decimal place digit is 4 so do not round up • expressed to 1 decimal place the number is 24.5 g Similarly: • express 0.167 mol/dm^3 to 2 decimal places • the third decimal place digit is 7 so round up • expressed to 2 decimal places the number is 0.17 mol/dm^3	Observe on a given sample activity Provide feedback Check on a sample of exercises Provide feedback
• Define significant figures • Determine the number of significant figures in a calculated result			

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Use the scientific notation in writing very large or very small numbers	• Significant figures • Scientific notation	Students should show that a similar system is used for significant figures: • to express a value to the n^{th} significant figure they look at the value of the $n+1^{th}$ digit • if the $n+1^{th}$ digit is 5 or more they round up the n^{th} digit • if the $n+1^{th}$ digit is 4 or less they leave the n^{th} digit unchanged Students should be talked through some examples and then attempt some examples for themselves e.g. • express 348 °C to 2 significant figures • the third significant digit is 8 so round up • expressed to 2 significant figures the number is 350 °C Similarly: • express 4.381 g to 3 significant figures • the fourth significant digit is 1 so do not round up • expressed to 3 significant figures the number is 4.38 g Students should identify that it is not possible to express an answer to a higher degree of accuracy that the data from which it is derived. For example: • The mass of a metal block = 15.2 g • The volume of the metal block = 5.6 cm^3 • The density of the metal = mass/volume = 2.714857 • But the mass and the volume are expressed only to one decimal point so the density cannot be given any more accurately than one decimal point = 2.7 g/cm^3 Students should realize the problems of writing very large or very	Observe on a given sample of exercises Provide feedback Check on a sample of exercises Provide feedback

Competencies	*Contents*	*Suggested Activities*	*Assessment*
		small numbers in terms of the numbers of zeros involved e.g. 2300000, 0.000000154. They should show that scientific notation involves writing numbers to a common format in which there is: • One digit to the left of the decimal point • The remaining digits to the right of the decimal point • The number is multiplied by a power of ten • The power of ten is determined by number of places the decimal point must be moved to the left or right regenerate the number in its original format For example: • 2300000 = 2.3×10^{6} • 0.000000154 = 1.54×10^{-7} Students should practice writing very large and very small numbers in scientific format.	
• Define scientific method • Describe the major steps of the scientific method • Use scientific methods in solving problems • Demonstrate some experimental skills in chemistry	**2.2 Chemistry as experimental Science** *(10 periods)* • The scientific method • Some experimental skills in chemistry	Students should discuss in group and suggest the important steps apply in the scientific method. These are: • Identifying the problem - gathering information, devising a solution • Carrying out experiments – observation, measurement, recording, inferring • Examining the results of the experiment – analysis, generalisations, synthesis • Conclusions – explanation, prediction • Further experiments – checking predictions, accounting for unexpected results	Monitor the group discussion and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Describe the procedures of writing laboratory report	• Writing a laboratory report	Students should demonstrate laboratory safety rules and common safety labelling Students could be asked to suggest common laboratory apparatus and their use along with the required care and safety. This should include: • Reaction vessels such as beakers, flasks, funnels, boiling tubes and test tubes • Measuring equipment such as pipettes, burettes, balances and thermometers • Support and heating devices such as stand and clamp, tripod and gauze, spirit burner and Bunsen burner Students should develop the skills needed to carry out experimental work successfully. These should include: • Handling of apparatus • Accurate measurement • Careful observation • Safe practice with regard to themselves and others Students should exercise how to write an accurate and comprehensive report on each piece of work carried out in the laboratory. This should include: • An explanation of the method used • The apparatus used including diagrams if necessary • Accurate observations • Use of tables to record data • Examine the results • Conclusions based on observations and results	Monitor the laboratory demonstration and give feedback Summarize the basic laboratory safety rules Give feedback to the laboratory reports

Competencies	***Contents***	***Suggested Activities***	***Assessment***
		• Present data in graphs or charts using simple software like Excel • Identification of any patterns which may be evident • Inclusion of chemical equations where appropriate • Calculations if appropriate Students could be given some practical activities to carry out where emphasis is placed on scientific method. Students should be encouraged to type their reports and submit both in soft and hard copy	

Unit 3: Structure of the atom *(29 periods)*

Unit outcomes: Students will be able to:

- Discuss the development of Dalton's atomic theory and modern atomic theory;
- Explain the discovery of the electron and the nucleus;
- Differentiate the terms like atomic number, mass number, atomic mass, isotope, energy level, valence electrons and electron configuration;
- Develop skills in
  - determining the number of protons, electrons and neutrons of atoms from atomic numbers and mass numbers,
  - calculating the atomic masses of elements that have isotopes,
  - writing the ground state electron configurations of atoms using main energy levels and drawing diagrammatic representations of atoms.
- Demonstrate scientific inquiry skills: observing, comparing and contrasting, communicating, asking questions, and applying concepts.

Competencies	*Contents*	*Suggested activities*	*Assessment*
Students will be able to: • State briefly the history of development of atomic nature of substances • State the law of conservation of mass and illustrate using	***3.Structure of the atom*** **3.1.Historical development of the atomic theories of matter** ***(3 period)*** **3.2 Fundamental laws of chemical reactions** *(6 periods)* • The law of conservation of mass	Students should be able to discuss: • early Greek concepts of the composition of matter based on visionary beliefs but not on evidence (Democritus Vs Zeno of Elea) Students should be asked to explain the idea of atoms as the building blocks from which all matter is formed that was first suggested by the ancient Greeks although. Students should be given a chance to express their feeling about "in all types of chemical reactions mass is neither created nor destroyed. Students should be able to quote the law of conservation of mass: 'Matter cannot be created nor destroyed in a chemical reaction'	Facilitate the discussion and give feedback Listen students responses and give summary

Competencies	*Contents*	*Suggested activities*	*Assessment*
examples • Describe the law of conservation of mass using simple experiments		Students should be requested to carry out an experiment to prove the law of conservation of mass. For example using the reaction between silver nitrate solution and dilute hydrochloric acid: $HCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + HNO_3$ • Place dilute hydrochloric acid in a conical flask to a depth of about 1 cm • Tie a thread of cotton around the top of a test tube • Half fill the test tube with silver nitrate solution • Place the test tube inside the conical flask so that it is held on a slant by the thread and place a bung in the top of the flask to hold the thread in place • Weigh the conical flask and contents • Tilt the flask so the silver nitrate solution pours into the dilute hydrochloric acid and a white precipitate of silver chloride is produced • Reweigh the conical flask and contents From their experiment students should show that the mass of the products is equal to the mass of the reactants. Students could also use the reaction between barium nitrate and sodium sulphate: $Ba(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaNO_3(aq)$ • Make up solutions containing 2.61 g of barium nitrate and 1.42 g of sodium sulphate	Guide students in the laboratory and monitor the practical activities

Competencies	*Contents*	*Suggested activities*	*Assessment*
		• Mix the solutions • Filter off the insoluble barium sulphate and dry it (2.33 g) • Evaporate the water from the filtrate and weigh the residue of sodium nitrate (1.70 g) Students should find that, within the limits of experimental error, the mass of the products equals the mass of the reactants.	
• Describe Dalton's atomic theory	**3.3 Atomic theory** *(6 periods)* • Dalton's atomic theory	Students should be asked to state the atomic theory proposed in 1808 by the scientist John Dalton in which he suggested that: 1. Elements are made of small particles called atoms 2. Atoms can neither be created nor destroyed 3. All atoms of the same element are identical and have the same mass and size 4. Atoms of different elements have different masses and size 5. Atoms combine in small whole numbers to form compounds Students should discuss each point in Dalton's atomic theory and determine whether it is still valid today.	Listen the response and give feedback
• Describe the modern atomic theory	• Modern atomic theory	Students should be sked to recognize that at the time that Dalton's theory was proposed nothing was known about the internal structure of the atom. As a result of our increasing knowledge about atomic structure we now know that statement #2 and statement #3 are no longer true. Students should attempt to modify Dalton's statements in the light	Ask questions whether students recognized the weakness of Dalton's theory

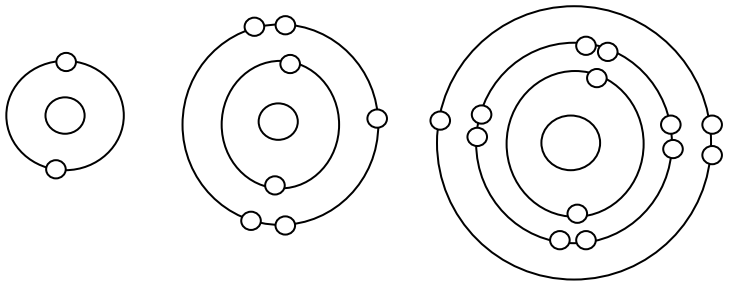
Competencies	*Contents*	*Suggested activities*	*Assessment*
• Compare and contrast Dalton's atomic theory and the modern atomic theory		of modern knowledge about the atom. The modified statements could be: 1. Elements are made of small particles called atoms 2. Atoms cannot be created or destroyed during ordinary chemical reactions 3. All atoms of the same element have the same atomic number but may vary in mass number due to the presence of different isotopes 4. Atoms of different elements are different 5. Atoms combine in small whole numbers to form compounds Students should show the symbols that Dalton used to represent atoms of different elements and discuss why these symbols are no longer used.	Check students responses and give feedback
	3.4 Discoveries of fundamental subatomic particles and the atomic nucleus *(6 periods)*	Students should be asked to correlate our modern understanding of atomic structure came about as a result of the discovery of its component particles.	Observe students responses and give summary
• Explain the discovery of electron • Explain the discovery of nucleus	• Discovery of the electron • Discovery of the nucleus	Students should be asked to tell that the electron was discovered by the physicist J.J. Thomson. Students should be able to give the J.J Thomson's model of atoms Students should be asked to tell that the nature of the nucleus of an	Listen students responses and give feedback

Competencies	*Contents*	*Suggested activities*	*Assessment*
		atom was discovered by the physicist Rutherford and two of his students; Geiger and Marsden Students should be able to give the Rutherford's model of atoms Students should able to describe that: • The nucleus of an atom is positively charged • Most of the mass of an atom is in the nucleus • There are large spaces within an atom Students could research why Rutherford predicted the existence of the neutron and how this was demonstrated by Chadwick in 1932.	Check the students responses and give feedback
• Explain the discovery of neutron	• Discovery of the neutron	Students should be able to tell the neutron was discovered by James Chadwick in 1932 Students should be able to give the James Chadwick's model of atoms	
• Write the relative	**3.5 Composition of an atom and the isotopes** *(8 periods)* • Electrons, protons and	Students should be able to give the relative mass and charge of each of the fundamental particles in an atom and state in which	Check students responses and give

Competencies	*Contents*	*Suggested activities*	*Assessment*
charges of an electron a proton and a neutron • Tell the absolute and relative masses of an electron, a proton and a neutron	neutrons	part of the atom it is found. Students should be asked to tell the masses of the sub-atomic particles are very small but they do have absolute values: • Neutron – 1.675×10^{-24}g • Proton – 1.672×10^{-24}g • Electron – 9.11×10^{-28}g Students should compare the mass of proton with the mass of a neutron. They should also recognize that the mass of an electron is negligible (too small).	feedback Listen students responses and give summary
• Tell the number of protons and electrons in an atom from the atomic number of the element • Determine the number of neutrons from given values of atomic numbers and mass numbers	• Atomic number and mass number	Students should be asked to describe the composition of the nucleus (protons and neutrons). Students should be asked to describe: • The atomic number of an atom is equal to the number of protons in the nucleus • The atomic number is also equal to the number of electrons in a neutral atom • The mass number of an atom is equal to the number of protons + the number of neutrons in the nucleus • The number of neutrons in the nucleus of an atom is equal to the mass number minus the atomic number Students should find the number of protons and electrons in atoms from their atomic numbers. Students should find the atomic numbers and mass numbers of atoms of some elements and use them to calculate the number of	Check students responses and give feedback Give a sample of exercises Provide feedback

Competencies	*Contents*	*Suggested activities*	*Assessment*
• Explain the terms atomic mass and isotope	• Atomic mass, and isotope	neutrons present in each atom. Students should be able to indicate the atomic number and the mass number of an atom of an element by writing the mass number as subscript and the atomic number as superscript, placing them both before the symbol of the element Mass no SYMBOL OF THE ELEMENT atomic no Students should explain that in the atoms of an element: • the number of protons is always the same • the number of neutrons varies slightly Students should show atoms of the same element which have different numbers of neutrons will have different mass numbers and are called isotopes. Students should show a natural sample of an element is likely to contain a mixture of two or more isotopes. In determining the atomic mass of the element, students must take into account that it is a mixture of isotopes with different mass numbers. Students should be asked to identify: • Some elements are composed almost entirely of one isotope therefore the atomic mass of the element will be the same as the mass number of the isotope – for example carbon exists as a mixture of the isotopes carbon-12, carbon-13 and carbon-14,	Listen students responses and give feedback Check on a sample of exercises Provide feedback

Competencies	*Contents*	*Suggested activities*	*Assessment*
• Calculate the atomic masses of elements that have isotopes.		but carbon-12 accounts for 98.9% of the element. • Some elements contain significant proportions of different isotopes and an accurate value for the atomic mass is obtained by taking the mass number and percentage of each isotope into account – for example, boron exists as a mixture of the isotope's boron-10, 20%, and boron-11, 80%. Therefore, both isotopes make a significant contribution to the atomic mass of boron. The atomic mass is equal to the weighted average mass of its isotopes. Students should calculate the atomic mass of boron using the following method: $10 \times \frac{20}{100} + 11 \times \frac{80}{100} = 2 + 8.8 = 10.8$ Students could apply this method to find accurate values for the atomic masses of other elements such as copper and chlorine.	
• Describe main energy level	• Main energy levels	Students should be asked to give: • Energy main levels by numbers 1, 2, 3, 4, etc. or letters K, L, M, N etc.	Give a sample of exercises Provide feedback
• Define electronic configuration • Write the ground state electronic		Students should be able to write the ground state electron configurations of the elements on main shells: • Hydrogen – 1	Give a sample of exercises and

Competencies	*Contents*	*Suggested activities*	*Assessment*
configuration of the elements • Draw diagrams to show the electronic configuration of the first 20 elements • Write the electronic configuration of the elements using sub energy levels	- Electronic configuration on main shells - Valence electrons	• Helium – 2 • Lithium – 2, 1 etc. Students should be able to draw diagrams to show the electron configurations of the first 20 elements on main shells Students should consider some examples. This could include the diagrammatic representation of the electronic configurations of the elements He, N & Al  $_{2}$He : 2 $_{7}$N : 2, 5 $_{13}$Al : 2, 8, 3 Students should write electronic configuration of the elements using main energy levels for the first 20 elements. Students should identify that the electrons in the outermost orbital have the highest energy and are called valence electrons. Students should describe valence electrons are:	Provide feedback Check students activity and give feedback Check on a sample of exercises

Competencies	*Contents*	*Suggested activities*	*Assessment*
• Describe valence electrons		• furthest from the nucleus of the atom • the most easily lost responsible for the chemistry of the element	Provide feedback

Unit 4: Periodic classification of elements (20 periods)

Unit outcomes: Students will be able to:

- Explain the historical development of the periodic classification of the elements
- Describe the periodic classification of the elements.
- Develop the skills of correlating the electron configuration of elements with the periodicity of the elements, predicting the trends of periodic properties of elements in the periodic table.
- Develop skills of classifications based on patterns in chemistry.
- Demonstrate scientific inquiry skills: observing, inferring, predicting, classifying, comparing and contrasting, making models, communicating, measuring, asking questions, interpreting illustrations, drawing conclusion, applying concepts and problem solving.

Competencies	Contents	Suggested Activities	Assessment
Students will be able to: • Describe periodicity • State Mendeleev's Periodic law • State modern periodic law • Describe period • Describe group	***4. Periodic classification of the elements*** **4.1 Historical development of periodic classification of the elements (3 *period)*** • Dobereiner's Triads • Newland's Octaves. **4.2 Mendleev's classification of the elements (2 *period)*** • Mendleev's periodic law • periodicity **4.2 The modern Periodic Table** *(15 periods)* • The Periodic law • Groups and periods	•Students should describe that in classifying elements, scientists were guided by the similarities in chemical properties. The elements are arranged in a table in such a way that elements with similar chemical properties appear at regular intervals or periods. •Students should revise early attempts of classifications of elements such as Dobereiner's Triads and Newland's Octaves. • Students could asked to explain the work of Mendeleev, his foresight in leaving a gap between silicon and tin, and his predictions about the properties of the missing elements eg. Germanium. • Students should be asked to differentiate that the rows of the Periodic Table are called periods. They should identify that elements in the same period: ○ Have the same number of main energy levels ○ Increase in atomic number by one unit passing across the period ○ Decrease in metal properties passing from left to right • Students should know that the columns of the Periodic Table are called groups. They should understand that elements in the same group: ○ Have the same number of electrons in the outermost shell	Listen students responses and give feedback Listen students responses and provide feedback • Give a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Explain the relationship between the electronic configuration and the structure of the modern Periodic Table • Describe the three classes of the elements in the modern Periodic Table • Explain the representative element blocks of the elements related with their electronic configuration • Give group names for the main group elements • Classify the periods into short, long and incomplete periods • Tell the number of groups	• Classification of the elements - The representative elements	○ Have similar chemical properties ○ Students should compare the electronic configurations of the first 20 elements with their positions in the Periodic Table. They should see that: ○ Elements whose valence electrons are in s orbital appear to the left-hand side (in Groups 1 and 2) ○ Elements whose valence electrons are in p orbital appear to the right-hand side (in Groups 3 to 8) ○ Prepare the modern periodic table and present for class • Students should identify that some groups have traditional names and others as family of the first member in the group. which are often used in textbooks: Group 1 – alkali metals Group 2 – alkaline earth metals Group 3 - boron family	Check on a sample exercises and give feedback Check the chart and give feed Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
and periods in the modern Periodic Table • Tell the number of elements in each period • Predict the period and group of an element from its atomic number • Tell the block and group of an element from its electronic configuration • Describe the four major trends (atomic size, ionization energy, electron affinity and electro negativity) in the periodic table	• The major trends in the periodic table (atomic size, ionization energy, electron affinity and electro negativity)	Group 4 - carbon family Group 5 - nitrogen family Group 6 - oxygen family Group 7 – halogens Group 8 – noble gases • Students should be identify that some periods are long while others are short and are in incomplete. Students should be able to give examples of each • Students should describe the number of elements each period of the Periodic Table. Students should be able to: ○ Identify an element from its group and period ○ Identify the group and period of the representative element from its atomic number ○ Identify the representative element block to which an element belongs from its electronic configuration ○ Students should be asked to discuss the major trends in the periodic table: - • atomic size • ionization energy • electron affinity • electro negativity	Check on a sample exercises and give feedback Monitor the discussion and give summary

Unit 5: Chemical bonding (27 periods)

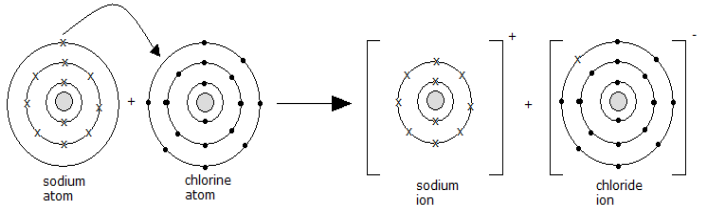
Unit outcomes: Students will be able to:

- Discuss the formation of ionic, covalent and metallic bonds;
- Explain the general properties of substances containing ionic, covalent and metallic bonds;
- Develop the skills of drawing the electron dot or Lewis structures for simple ionic and covalent compounds;
- Describe the origin of polarity within molecules;

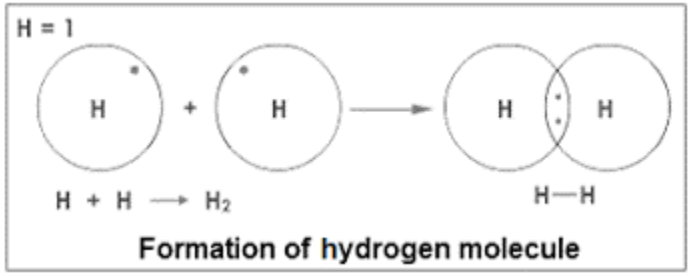
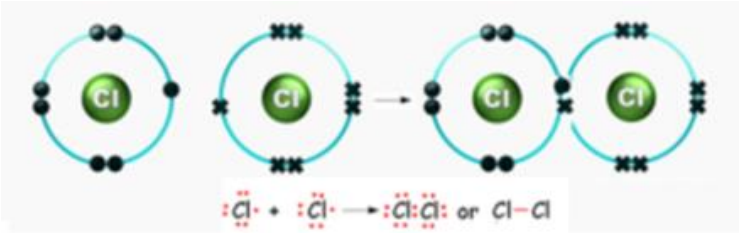
Competencies	Contents	Suggested Activities	Assessment
Students will be able to:	***5. Chemical bonding***		
	5.1 Chemical bonding		
• Define chemical bonding • Describe why atoms form chemical bonds	*(5 period)*	Students should describe that a chemical bond is any force of attraction between two particles. The particles may be atoms, ions or molecules. Students should explain that atoms form bonds in order to achieve a more stable electron arrangement – a full outer shell of electrons. This can be achieved by: • Transferring one or more electrons – ionic bonding • Sharing one or more pairs of electrons – covalent bonding Energy changes occur during bond formation – these usually result in the final substance being more stable. Students should describe that atoms which already have a full outer shell of electrons – the elements in Group 8 (noble gases) – have little chemistry as they do not readily form bonds.	Listen students responses and give feedback Check on a sample exercises and give feedback
	5.2 Ionic bonding *(6 periods)*		
• Explain the term ion	• Formation of ionic bonding	Students should explain that an ion is an atom which has lost or gained one or more electrons.	

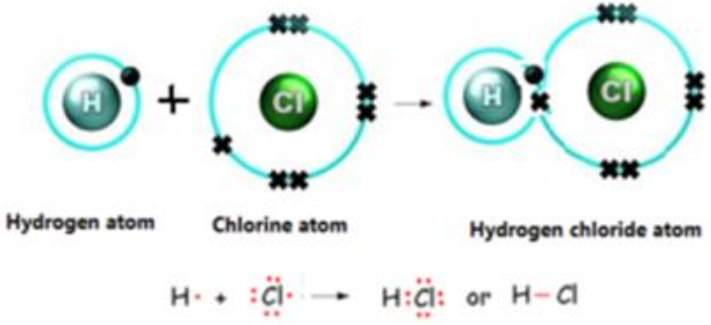
Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Elucidate the formation of ions by giving examples • Define ionic bonding • Describe the formation of an ionic bond		• Metals tend to lose electrons to form positively charged ions or cations • Non-metals tend to gain electrons to form negatively charged ions or anions • Hydrogen forms both a cation, H^+ (hydrogen ion), and an anion, H^- (hydride ion) Students should discuss the relationship between position of elements in the periodic table to the ion formed by them: Group 1 – M^+ e.g. Na^+ Group 2 – M^{2+} e.g. Mg^{2+} Group 3 – M^{3+} e.g. Al^{3+} Group 5 – X^{3-} e.g. N^{3-} Group 6 – X^{2-} e.g. O^{2-} Group 7 – X^- e.g. Cl^- Students could be asked to write the formulas of the ions formed by atoms of different elements. Students should describe that the easiest way for a metal to achieve a full outer shell of electrons is by losing electrons e.g. • sodium atom (2.8.1) → sodium ion (2.8)	Monitor the discussion and provide summary Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Give examples of simple ionic compounds • Draw Lewis structures or electron-dot formulas of simple ionic compounds	• Lewis Formulas of ionic compounds	The alternative to this would be for the sodium atom to gain 7 electrons which would be very unstable. Similarly the easiest way for a non-metal to achieve a full outer shell of electrons is by gaining electrons e.g. • chlorine atom (2.8.7) → chloride ion (2.8.8) The alternative to this would be for the chlorine atom to lose 7 electrons which would require a large amount of energy and produce an unstable ion. Students should be explain that ionic bonding is the result of forces of attraction between oppositely charged ions. Students should be able to show how an ionic bond is formed by the transfer of one or more electrons from a metal atom to a non-metal atom. Students should be asked to represent the formation of an ionic compound using Lewis structure. An example of dot and cross diagram (Lewis formula) for sodium and chlorine to form sodium chloride could be given as follows.	Listen and give feedback Check on a sample exercises and provide feedback

Competencies	Contents	Suggested Activities	Assessment
• Describe the general properties of ionic compounds.	• General properties of ionic compounds	 (2,8,1) (2,8,7) (2,8) (2,8,8) Students should also be able to represent the Lewis structure using symbols. eg. Na + Cl $\rightarrow$ Na^+ $[Cl]^-$ Students should explain that, when forming ions, the name of a non-metal takes the ending –ide e.g. nitride, oxide, chloride. Students could name the ionic compounds formed from given metals and non-metals and draw Lewis structures to show the ionic bonding. Students should be asked to discuss general properties of ionic compounds including: • crystalline nature • high melting points and boiling points • ability to conduct an electric current when molten or in aqueous solution	Check on a sample exercises and give feedback Listen students responses and give feedback Monitor the discussion and give summary

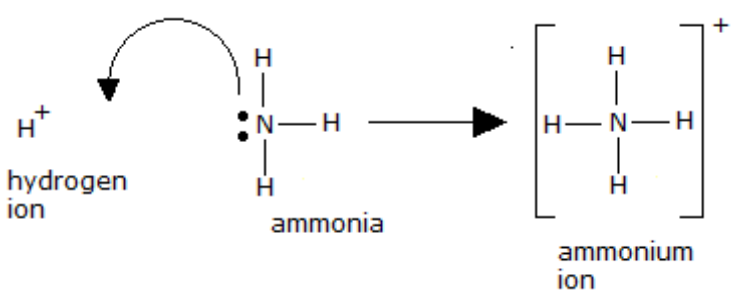
Competencies	Contents	Suggested Activities	Assessment
• Investigate the properties of given samples of ionic compounds.		• solubility in polar solvents like water Students should explain the solubility in water in itself is not a proof that a compound is ionic. There are ionic compounds which are effectively insoluble in water, and covalent compounds like glucose which are very soluble. Students could be given samples of ionic compounds and asked to investigate their properties such as solubility, physical state, conductivity	Listen students responses and give feedback Check on a sample exercises, observe students activities, and give feed
	5.3 Covalent bonding *(14 periods)*		
• Define covalent bonding • Describe the formation of a covalent bond	• Formation of Covalent bond	Students should define that covalent bonds are formed when atoms share pairs of electrons. Students should explain the bond formation due to the electrostatic attraction between electrons and positively charged nuclei of two atoms. Students should be requested to show how a covalent bond is formed by the sharing of a pair of electrons.	Listen students responses and give feedback
• Draw Lewis structures or	• Lewis's formula of		

Competencies	Contents	Suggested Activities	Assessment
electron-dot formulas of simple covalent molecules • Give examples of different types of covalent molecules	covalent molecules.	Students should be given a chance to represent the formation of a covalent molecule using Lewis electron dot formula Symbols or diagrams can be used to illustrate it. $H + H \rightarrow H_2$  Formation of hydrogen molecule Eg. $Cl + Cl \rightarrow Cl_2$  Eg. H + Cl → HCl	Check on a sample exercises and give feedback

Competencies	Contents	Suggested Activities	Assessment
			
		Students should be requested to practice drawing Lewis structures for common covalent compounds. These could include water, ammonia and methane (H_2O, NH_3, CH_4)	Check on a sample exercises and give feedback
		There are also double and triple bonds between atoms in some molecules e.g., O_2 and N_2 • O=O in oxygen • N≡N in nitrogen	
		Students should be asked to practice drawing Lewis structures for common covalent compounds in which there are double and triple bonds. Students could draw Lewis's electron dot formula for other	Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Make models of covalent molecules to show single, double and triple bonds using sticks and balls or locally available materials. • Discuss the polarity in covalent molecules	• Polarity in covalent molecules.	compounds e.g., CO_2, CO. Students should be asked to construct models of simple molecules to show covalent compounds in which there are single bonds, double bonds and triple bonds, using locally available materials (mud, fruit and sticks) Students should be asked to describe that the sharing of the pair of electrons in a covalent bond depends on the attraction of the electrons. This is related to the electro negativity of the atom. Students should be asked to discuss the sharing of the pair of electrons in molecules between two atoms of the same element: • the electrons are attracted equally by the two atoms • the electron pair is shared equally Students should discuss the sharing of the pair of electrons in molecules formed between atoms of different elements e.g., hydrogen and chlorine in hydrogen chloride. • the chlorine atom is more electronegative than the hydrogen atom • the chlorine atom attracts the electrons in the covalent bond more strongly	Observe and evaluate students work Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Distinguish between polar and non-polar covalent molecules • Define coordinate covalent (dative) bond • Elucidate the formation of coordinate covalent bond using suitable examples	• Coordinate covalent bond (dative bond)	• the pair of electrons in the covalent bond are positioned closer to the chlorine atom than the hydrogen atom • the chlorine end of the bond is slightly negative relative to the hydrogen end • the relative charge is shown using the symbols δ^+ and δ^- • the bond is polarised and shown as $H^{\delta+}$ $Cl^{\delta-}$ Students should be requested to identify polar bonds in covalent compounds and mark their polarity Students should be encouraged to discuss the structure of different covalent bonds and determine whether they are non-polar or polar. Students could be asked to discuss how polarity affects the properties of covalent compounds. Students should explain that another type of covalent bond exists in which both of the electrons which form a covalent bond between atoms is donated by one of the atoms. This is a coordinate covalent bond or dative bond. This could include the formation of ammonium ion (NH^+_4) from	Monitor the discussion and provide summary Listen the students responses and provide feedback

Competencies	*Contents*	*Suggested Activities*	*Assessment*
		hydrogen ion (H^+) and a molecule of ammonia (NH_3)  	
• Explain the general properties of covalent compounds	• General properties of covalent compounds	Students should be asked to show the formation of coordinate bonds in some familiar substances including: • hydronium ion, H_3O^+ • carbon monoxide, CO Students should identify that non-bonding pair of electrons is referred to as a lone pair. Students should describe the role of lone pairs of electrons in coordinate bonding. Students could name the covalent compounds and draw Lewis structures to show the covalent bonding.	
• Investigate the properties of given samples of covalent compounds.		Students should discuss general properties of covalent compounds including: • Liquids or gases, and some are solids.	Check on a sample exercises and give feedback Monitor the

Competencies	Contents	Suggested Activities	Assessment
		• low melting points and boiling points • do not conduct an electric current when molten or in aqueous solution • solubility in non-polar solvents • insolubility in polar solvents like water Students could be given samples of covalent compounds and asked to investigate their properties such as physical state, solubility, conductivity, etc.	discussion and give summary
• Discuss the formation of metallic bond	**5.4 Metallic bonding** *(2 period)* • Formation of metallic bond	Students should identify that metals consist of a matrix of positively charged ions in a sea of delocalised electrons. Students should discuss why metals are able to lose valence electrons so easily to give this structure. Students should explain and that metallic bonding is the result of electrostatic attraction between the positively charged metal ions and the negatively charged delocalised electrons. Students could be asked to discuss how the strength of the	Check on a sample exercises and give feedback Monitor the discussion and give feedback Listen the students responses and give feedback Monitor the

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Explain the electrical and thermal conductivity of metals in relation to metallic bonding. • Make a model to demonstrate metallic bonding.	• Properties of metallic bond	metallic bond is related to the atomic radius of the metal atom and the number of valence electrons which are delocalised. Metallic bonding is strongest where metals have small atomic radii and lose a large number of valence electrons. Students should explain the ability of metals to conduct both heat and electricity is related to the movement of delocalised electrons. These are able to transfer energy and charge through the metal. Students could be requested to discuss how some of the other properties of metals, such as malleability and ductility are related to metallic bonding. Students could demonstrate the difference in strength of some in the surrounding.	discussion and give summary Listen the students responses and give feedback Monitor the discussion and give summary Observe and give feedback

Chemistry Syllabus

For Grade 10

General Objectives of Grade 10 Chemistry

To develop understanding and acquire knowledge of:

- Classes of organic and inorganic compounds and some of their uses
- formation of chemical bonding and properties of compounds formed by different types of bonds
- extraction, chemical properties and uses of metals and nonmetals
- The interconvert ion of electrical and chemical energies and their applications
- Uses of natural resources and their protection
- extraction, chemical properties and uses of metals and nonmetals
- types, properties and processes of formation of solutions
- Importance of electrochemical cells in daily life

To develop skills and abilities of:

- Handling and using science apparatuses and laboratory substances correctly
- preparing solutions of specific concentration and solving quantitative problems involving solutions;
- conducting experiments to observe and analyze the physical properties of substance and determine the type of bonding
- Designing and conducting simple experiments appropriate to their level
- Applying conservations of mass laws to calculate relevant quantities

To develop the habit and attitude of:

- Appreciating the roles of chemistry in energy production
- Having an interest and curiosity towards natural resources
- Responsible about safety of oneself, and protection of natural resources
- Being honest and accurate in recording and validating data

Unit 1: Chemical reactions and stoichiometry (23 periods)

Unit outcomes: Students will be able to:

- Define the basics of chemical reaction and describe the four major types of reaction
- Develop skills in writing and balancing chemical equations
- Understand oxidation - reduction reactions and analyse redox reactions by specifying the oxidizing agent, the reducing agent, the substance reduced or oxidized
- Understand fundamental laws of chemical reactions and know how they are applied
- Develop skills in solving problems based on chemical equations (mass - mass, volume - volume and mass - volume problems).
- Develop skills in determining the limiting reactant, theoretical yield, actual yield and percentage yield.
- Demonstrate scientific inquiry skills: observing, inferring, predicting, classifying comparing and contrasting, communicating, measuring, asking questions designing experiments, interpreting data, drawing conclusions, applying concepts, relating cause and effect and problem - solving.

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Students will be able to: • Define chemical reaction	***1. Chemical reactions and stoichiometry*** **1.1 Introduction** *(1 period)*	Students should be asked to explain that a chemical reaction is a change that takes place when one or more substances, called reactants, react alone or with each other to produce one or more new substances, called products. Reactants → Products	Listen students responses and give feedback
• Give some examples of chemical reactions		Students should be requested to give examples of chemical reactions. The students could also ask to describe the examples of changes brought by the chemical reactions. These could include: • Burning of wood • rusting of iron • Fermentation • Souring Tej and digestion of food	Listen students responses and provide summary
• List the four types of chemical reactions	**1.2 Types of chemical reactions** *(3 periods)* • Combination reaction	Students should be asked to discuss in group classes of chemical reactions and present each group for the class Students should explain that combination or synthesis reactions involve the reaction of one element with another to form a compound.	Monitor the discussion and give summary Listen students responses and give
• Define combination			

Competencies	***Contents***	***Suggested Activities***	***Assessment***
reaction and give examples • Conduct some experiments on combination reactions in groups		Students should discuss in group on examples of combination reactions. These could include: • Sodium + chlorine = sodium chloride • Carbon + oxygen = carbon dioxide • Copper + oxygen = copper (II) oxide • Iron + sulphur = iron sulphide • Hydrogen + oxygen = water • Magnesium + oxygen = magnesium oxide Students should discuss the general features of a combination reaction. Students could carry out some combination reactions.	feedback Monitor the discussion and give summary
• Define decomposition reaction and give examples • Conduct some experiments on decomposition reactions in groups	• Decomposition reaction	Students should be given a chance to explain that decomposition reactions involve a reactant breaking down to produce two or more products Students should carry out experiments on some decomposition reactions and write a report on: • Thermal decomposition of Group 1 nitrates to nitrites and oxygen • Thermal decomposition of Group 2 and Transition	Monitor the discussion and give summary Observe students activities and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Define single displacement reaction and give examples	• Single displacement reaction	Metal nitrates to oxides, oxygen and nitrogen dioxide • Thermal decomposition of Group 2 and Transition Metal carbonates to oxides and carbon dioxide Students should discuss the general features of a decomposition reaction. Students could carry out some decomposition reactions. Students should explain single displacement reactions involve a more reactive element displacing a less reactive element from a compound Students should give same examples of single displacement reactions. These could include: • Reactive metals with water – displacing hydrogen e.g., sodium + water • Reactive metals with dilute acids – displacing hydrogen e.g., zinc + dilute hydrochloric acid • Metal – metal ion reactions – atoms of a more reactive element displace ions of a less reactive metal from solution e.g., iron + copper (II) sulphate solution • Halogen – halide ion reactions – atoms of a more reactive halide displace ions of a less reactive halide from solution e.g., chloride + potassium bromide	Listen students responses and give feedback Check on a sample exercises and give feedback Listen students

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Conduct some experiments on simple displacement reactions in groups • Define double decomposition reaction and give examples • Conduct some experiments on double displacement reactions in group	• Double displacement reaction	solution. Students should discuss the general features of a single displacement reaction. Students could carry out some double decomposition reactions and write a report Students should discuss in group on double decomposition reactions and give same examples. These could include: • Reactions to precipitate silver halides • Reactions to precipitate lead halides • Reactions to precipitate barium sulphate Students should discuss the general features of a double decomposition reaction. Students could carry out some double displacement reactions	responses and give feedback Observe students activities and give feedback Listen students responses and give feedback Observe students activities and give feedback Check on a same exercises and give

Competencies	***Contents***	***Suggested Activities***	***Assessment***
			feedback
• Explain the conventions used to write chemical equation	**1.3 Chemical equations** *(3 periods)* • Writing chemical equation	Students should be requested to apply the following steps to write an equation: 1.Write a word equation 2.Substitute the words by symbols and formulas 3.Balance the equation so that there are equal numbers of atoms of each type of element on each side of the equation	Check on a same exercises and give feedback
• Balance chemical equations using: - inspection method - the Least Common Multiple (LCM) method -algebraic method	•Balancing chemical equation	Students should be asked to balance an equation: •by inspection method •by the least common multiple method •by algebraic method	Listen students responses and give feedback
• Define redox reactions • Define the terms oxidation and reduction in terms of electron transfer	**1.4 Oxidation and reduction reactions** *(5 periods)* • Oxidation • Reduction	Students should describe that a redox reaction is a reaction that involves transfer of electrons. Students should explain that the term redox' is used to describe oxidation and reduction reactions and that these reactions occur simultaneously. Students should be asked to define oxidation as a loss of electrons and reduction as a gain of electrons. They should identify in a redox reaction: • the oxidised species loses one or more electrons • the reduced species gains one or more electrons	Check on a sample exercises and give feedback Listen students responses and give
• Define oxidation number			

Competencies	***Contents***	***Suggested Activities***	***Assessment***
(oxidation state) • State oxidation number rules. • Determine the oxidation number of an element in a given formula • Determine the oxidation number of an element in a given formula • analyse the oxidizing and reducing agents	• oxidation number	feedback Students should describe the oxidation number or oxidation state: • is the charge that the atom carries in its compounds • refers to a single atom of the element • has both sign and numerical value Students should be asked to state oxidation number rules. Students should be requested to deduce the oxidation number of elements in compounds from their formulas Students should do simple examples e.g. $MgCl_2$ • oxidation state of Mg = +2 • oxidation state of Cl = -1 And more complex examples where an atom is part of an ion e.g. SO_4^{2-} • oxidation state of O = -2 • total oxidation state of O=4 x -2 = -8 • overall charge on the ion = -2 • oxidation state of S = -2 – (-8) = +6 Students should differentiate that an oxidising agent is one which brings about oxidation but is itself reduced. Students should be asked to give examples of oxidising	Listen students responses and give feedback Check on a sample exercises and give feedback Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Balance the given chemical reaction using oxidation number change method	• Oxidizing and reducing agents. • Balance redox reactions using oxidation number change method	agents which they may have already met in chemical reactions such as: • chlorine • potassium manganate(VII) • potassium chromate(VI) • potassium dichromate (VI) • sodium chlorate(V) • manganese(IV) oxide Students should be asked to balance a given chemical reactions using oxidation number change method that includes the following examples: - • Sodium + chlorine = sodium chloride • Carbon + oxygen = carbon dioxide • Copper + oxygen = copper (II) oxide • Iron + sulphur = iron sulphide • Hydrogen + oxygen = water	Check on a sample exercises and give feedback
• Solve molecular mass and formula mass problems based on the given chemical formula of compounds • State the mole concept and describe using example	1.5. Molecular and formula mass, the mole concept and chemical formula *(3 periods)* ▪ molecular mass and formula mass	Students should be requested to relate a molecular mass and formula mass chemical formula of a compound. Students should solve molecular mass and formula mass from chemical formula of the compound. Students should state the mole concept and describe it using examples.	Observe students activities and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Deduce percentage composition from formula mass/molecular mass of a compound • State empirical formula and molecular formula • Solve molecular formula problems based on the given empirical formula	▪ The mole concept ▪ Percent composition ▪ Chemical formulas: Determination of empirical and molecular formula	The student should differentiate the terms mole, molar mass and actual mass. Students describe molar mass and apply the mole concept to determine number of moles from given mass and molar mass. Students should be requested to calculate the percentage yield of a given compound using atomic weight of a given element in the compound and the formula mass of the compound using the equation: $\%composition = \frac{A}{B} \times 100$ Where A= total atomic mass of the element in the compound and B= Formula mass of the compound Students should relate empirical formula with molecular formula. Students should be asked to carry out calculations involving both empirical formula and molecular formula. Students should be asked to solve molecular formula problems based on the given empirical formula	Observe students activities and give feedback

Competencies	*Contents*	*Suggested Activities*	*Assessment*
	1.6 Stoichiometry *(8 periods)*		
• State the law of conservation of mass and illustrate using examples	1.6.1 Fundamental laws of chemical reactions	Students should be given a chance to express their feeling about "in all types of chemical reactions mass is neither created nor destroyed. Students should be able to quote the law of conservation of mass: 'Matter cannot be created nor destroyed in a chemical reaction'	Listen students responses and give summary
• Describe the law of conservation of mass using simple experiments		Students requested to carry out an experiment to prove the law of conservation of mass and write a report. For example, using the reaction between silver nitrate solution and dilute hydrochloric acid: $HCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + HNO_3$ • Place dilute hydrochloric acid in a conical flask to a depth of about 10ml • Tie a thread of cotton around the top of a test tube • Half fill the test tube with silver nitrate solution • Place the test tube inside the conical flask so that it is held on a slant by the thread and place a bung in the top of the flask to hold the thread in place • Weigh the conical flask and contents • Tilt the flask so the silver nitrate solution pours into the dilute hydrochloric acid and a white precipitate of silver chloride is produced • Reweigh the conical flask and contents From their experiment students should show that the mass of the products is equal to the mass of the reactants.	Observe students activities and give feedback
	• Molar ratios in balanced	Students should be asked to explain that stoichiometry is	

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Deduce mole ratios from balanced chemical equations	chemical equations.	the study of the different amounts of substances which react to give new substances. Students should describe the significance of the different numbers of reactant and product particles in a balanced chemical equation. Students should explain that a balanced chemical equation indicates the molar quantities of reactants and products involved in a reaction.	Listen students responses and give feed back
• Solve mass-mass problems based on the given chemical equation	• Mass-mass relationships.	Students should be requested to interpret a balanced chemical equation in terms of ratios of moles of the reactants and products. Students should interpret a variety of balanced equations in this way.	Listen students responses and give feedback
• Define molar volume		Students should be asked to use balanced chemical equations to deduce the ratio of reacting masses and use this to calculate the actual masses. For example to find the mass of AgBr produced from 1 gm of KBr: $KBr(aq) + AgNO_3(aq) \rightarrow KNO_3(aq) + AgBr(s)$	Check on a sample exercises and give feedback
• State Avogadro's principle		1 mole 1 mole 1 mole 1 mole 119 g 170 g 101 g 188 g • 119 g of KBr yields 188 g of AgBr • therefore 1.00 g of KBr yields $\frac{1.00 \times 188}{}$ = 1.58 g of	Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Solve volume-volume problems based on the given chemical equation	• Volume-volume relationships.	AgBr119 Students should be asked to carry out a number of similar calculations on reacting masses using equations with different mole ratios. Students should identify that one mole of gas particles occupies a volume of 22.4 litre at standard temperature and pressure (STP) 0 °C and 101.325 Kpa. Students should describe Avogadro's principle which states that:'equal volumes of different gases under the same conditions of temperature and pressure contain equal numbers of particles; Students should be asked to use balanced chemical equations to deduce the ratio of reacting volumes and use this to calculate the actual volumes. For example, to find the volume of HCl produced from 100ml of H_2: $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ 1 mole 1 mole 2 moles 22.4 L 22.4 L 44.8 L • 22.4 L of H_2 yields 44.8 L of HCl • 100 ml of H_2 yields $\frac{0.1 \times 44.8}{22.4}$ = 0.2 L = 200 ml of HCl	Check on a sample exercises and give feedback Listen students responses and give feedback Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Solve mass-volume problems based on the given chemical equation	• Mass - volume relationships.	Students should be requested to carry out a number of similar calculations on reacting volumes using equations with different mole ratios. Students should be asked to carry out calculations involving both mass and volume. For example, to find the volume of CO_2 produced from 0.50gm of $CaCO_3$ $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ 1 mole 1 mole 1 mole 100 g 56 g 44 g or 22.4 L • 100 g of $CaCO_3$ yields 56 g of CaO • 0.50 g of $CaCO_3$ yields $\frac{0.5 \times 56}{100}$ = 0.28 g • 100 g of $CaCO_3$ yields 22.4 L of CO_2 • 0.50 g of $CaCO_3$ yields $\frac{0.5 \times 22.4}{100}$ = 0.112 L Students should be given a chance to carry out a number of similar calculations on reacting masses and volumes using equations with different mole ratios. Students should describe that in a chemical reaction involving two reactants, the reaction will stop when all of one reactant has been used up no matter how much of the second reactant remains. Students should be requested to identify that when two	Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Describe limiting and excess reactants • Calculate the amount of limiting and excess reactants of a given chemical reaction • Show that the amount of product of a chemical reaction is based on the limiting reactant	• Limiting and excess reactants.	reactants are not in the mole ratio in which they react then one will be the limiting reactant and the other will be in excess. Students should be asked to carry out calculations on chemical reactions in which there is a limiting reactant. For example: $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$ 1 mole 2 moles 1 mole 1 mole 5.00 g of zinc is reacted with 3.65g of HCl • 5.00 g of zinc is $\frac{5.00}{65.4}$ = 0.076 mol • 3.65gof hydrochloric acid contains 3.65/ 36.5 = 0.1 mol. • The maximum amount of zinc that will react with 0.1 mol dilute hydrochloric acid is 0.050 mol • The dilute hydrochloric acid is the limiting reactant • The zinc is in excess • The amount of zinc that will remain at the end of the reaction is 0.076 – 0.050 = 0.026 mol which is 65.4 x 0.026 = 1.70 g • The amount of zinc chloride formed will be 0.050 mol which is (65.4 + 2 x 35.5) x 0.05 = 6.82 g • The amount of hydrogen gas formed will be 0.050 mol which is 22.4 x 0.050 = 1.12 L at room temperature and standard pressure Students should be requested to carry out a number of similar calculations, identifying the limiting reactant and	Listen students responses and give feedback Check on a sample exercises and give feedback Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Describe the terms theoretical yield, actual yield and percentage yield • Calculate the percentage yield of a chemical reaction from given information	• Theoretical, actual and percentage yields.	finding the maximum number of products that can be formed. Students should explain that: • given the equation for a chemical reaction and the quantities of reactants used, it is possible to calculate the yield of products that should be obtained – the theoretical yield • not all of the reactants in a chemical reaction may go to form a desired product; some may be used up in unwanted side reactions. The actual amount of product obtained is – the actual yield • the success of a reaction can be assessed by comparing the ratio of the actual yield to the theoretical yield to give – the percentage yield Students should be requested to calculate the percentage yield of a chemical reaction from a given data using the equation: $$\text{Percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$ Students should be asked to show that: • percentage yield will be between 0 – 100% • the higher the percentage yield the more successful the reacting	Listen students responses and give feedback Check on a sample exercises and give

Competencies	***Contents***	***Suggested Activities***	***Assessment***
			feedback Check on a sample exercises and give feedback

Unit 2: Solutions (20 periods)

Unit out comes: Students should be able to:

- List and explain the types of solutions;
- Describe the solution formation process, the rate of solution, the heat of solution & solubility;
- Describe the dependence of solubility on temperature & pressure of solution;
- Solve problems involving concentration of solutions & express the result in various units;
- Describe, using the concept of equilibrium, the behavior of ionic solutes in solutions that are unsaturated, saturated and supersaturated;
- Prepare solutions of required concentration by dissolving a solute or diluting a concentrated solution;
- Describe scientific enquiry skills along this unit: observing, classifying, comparing & contrasting, communicating, measuring, asking questions, drawing conclusion, applying concept and problem solving.

Competencies	*Contents*	*Suggested Activities*	
Students will be able to: • Define the terms mixture, homogenous and heterogeneous mixtures, solute, solvent, solution. • distinguish between homogenous and heterogeneous mixtures • describe suspension and colloids	***2. Solutions*** **2.1 Homogeneous and heterogeneous mixtures** *(1 period)* • Some basic definitions - mixture, homogeneous and heterogeneous mixtures, solute, solvent, solution • Suspension and colloids	• Student should describe that mixtures are divided in to three categories: suspensions, colloids, and solutions. A suspension is a dispersion of fine solid particles in a liquid or gas, removable by filtration. It could also separate into its components under the influence of gravity. A mixture of sand and water is an example. • Students should describe that in a solution, the particles of the solute are of the size of individual atoms, molecules or ions. • Students should identify that in a colloid the particle size is much larger than in a solution but not so large that they separate on standing. • Ask students to dissolve sand, Gentian Violet and bile in water in three different flasks. Set them aside and see if they become any clearer on standing for some time. Students might need to decant them after 30 minutes. Do you see any change upon further standing? Pass light through each mixture and see which one scatters light without separating on standing. What do you call this type of mixture? • Students should conclude that both suspension and colloid are examples of heterogeneous mixtures whereas solution is a homogeneous mixture. • Students should identify that a solution has at least two pure components: solute and solvent.	Listen students responses and give feedback Observe students activities and provide feedback Listen students responses and give feedback
• Explain the different types of solutions. • give examples for each types of solutions	**2.2 Types of solution** *(2 periods)* • Gaseous solutions	• Students should explain that solutions can assume the three physical states of matter and should describe the general characteristics of solutions formed by various combinations of gases, liquids and solids.	Listen students responses and provide summary

	• Liquid solutions • Solid solutions	• Students should discuss gaseous solutions form when a gaseous solute dissolves in a gaseous solvent. They also could give an example for such solutions. For example, nitrogen is taken to be the solvent and all other gases in air to be solutes. • Students should identify liquid solutions can have gaseous, liquid and solid solutes but the solvent is always liquid and give examples for each.	Monitor the discussion and give summary Check on a sample exercises and provide feedback
• present a report on how jewelry gold is made to class after a visit to nearby goldsmith	**2.3 The solution process**	• Students should explain solid solutions have no restriction on the state of the solute but the solvent has to be solid. For example, an alloy is a solid solution of two or more metals or metals and non-metals. • Ask students discuss how jewelry gold is made. • Students should visit a nearby goldsmith and compile repot in group.	Listen students responses and give feedback Guide the visit program and check the report
• explain how the "like dissolves like" rule depends on interparticle forces of interactions and predict relative solubilities; • define rate of dissolution; • define heat of solution,	*(5 periods)* • Liquid solutions and interparticle forces of attractions • The rate of dissolution • Energy changes in the solution process	• Students should describe the factors that control the solubility of substances in liquid solvents. • Students could explain that in order for substances to be appreciably soluble in each other, they must possess similar intermolecular attractive forces. • Students should describe that when a solute particle is placed in solution it becomes solvated, which is surrounded by solvent molecules to which it is	Listen students responses and give feedback

solvation energy and hydration energy. • apply the concept of heat of solution to the solution of ammonium nitrate crystal. • apply the concept of heat of solution to the solution of sodium hydroxide crystal; • explain how heat of solution is influenced by the inter particle interaction forces. • describe the distinctions among unsaturated, saturated and supersaturated solutions. • Prepare unsaturated and saturated solutions of sodium sulphate • prepare supersaturated solution of sodium thiosulphate • explain the equilibrium nature of saturated solution • define solubility • describe the factors that affect solubility of substances • investigate the effect of temperature on solubility of sodium sulphate	- Heats of solution - Heats of hydration of ionic solid in water **2.3 Solubility as an equilibrium process** *(4 periods)* • Saturated, unsaturated and supersaturated solution • Effect of temperature on solubility	attracted. And when the solvent is water, the term hydrated is used. • Students should discuss how soaps and detergents work • Students should discuss rate of dissolution • Students should describe that the heat of solution is the energy absorbed or liberated when a solution is formed. • Students should identify for liquid solutions formed from a solvent A and solute B, o an ideal solution results when the A-B attractions are the same as the A-A and B-B attractions and for such a solution, $\Delta H_{soln} = 0$. o When the A-B attractions are greater than the A-A and B-B attractions, $\Delta H_{soln} < 0$ and the solution process is exothermic. o When the A-B attractions are weaker than the A-A and B-B attractions, $\Delta H_{soln} > 0$ and the solution process is endothermic. • Students should identify that for solutions of solids in liquids the lattice energy (the energy required to separate the solute particles from a crystal) and hydration energy (or salvation energy- the energy released when the solute particle is placed into the solvent cage) must be considered. • Students should identify that solutions are mixtures but not pure compounds. They can be unsaturated, saturated or even supersaturated. • Students should prepare unsaturated and saturated solution of sodium sulfate • Students should prepare supersaturated solution of	Monitor the discussion and give summary Listen students responses and give feedback Check on a sample exercises and give summary Check on a sample exercises and give feedback Observe students activities and give feedback

• conduct an experiment to determine solubility of table salt and sugar
 	
• state Henry's law
• use Henry's law to calculate concentration of gaseous solute in a solution
 	
• define concentration of a solution
• define mass percentage, ppm and ppb of a solute in a solution
• calculate the mass percentage, ppm and ppb of a solute in a solution from a given information
• define mole fraction
• calculate mole fraction of a solute and a solvent in a solution
• define molarity
• prepare molar solutions of different substances
	• Effect of pressure on solubility of gases
	
	- Henery's Law
	
	2.4Ways of expressing concentrations of solution
	
	(7 periods)
	
	• Mass percentage, ppm and ppb of solute
	• Mole fraction
	• Molarity
	• Normality
	• Molality
	• Conversion of concentration units
	
	2.5. Preparation of solutions
	(2 periods)
	
	• Diluting solutions
		sodium thiosulphate
		
		• Students should describe that a rise in temperature increases solubility if the dissolving of additional solute is endothermic and the solubility of gases, almost always decreases with increasing temperature.
		• Students should tell that the solubility of most of solid solutes increase with temperature whereas those of gases invariably decrease.
		
		• Students should explain that pressure has virtually no effect on the solubility of solids or liquids in liquid solvents and the solubility of gas molecules, are very markedly affected by pressure changes.
		
		• Students could apply Henry's law relates the concentration of a dissolved gas, Cg, to its partial pressure, Pg, over the solution.
		Cg = kgPg, where kg is Henry's law constant.
		
		• Students should describe the definitions of each concentration units.
		• Students should know that there are different ways in which the concentration of a solution can be described.
		• Students should express the concentration of a solution using appropriate units such as:
		  • Mass percentage, ppm and ppb of solute
		  • Mole fraction
		  • Molarity
		  • Normality and
		  • Molality
		• Students should prepare 1M, 1N and 1m solution of
			Listen students responses and give feedback
			
			Listen students responses and give feedback
			
			Check on a sample exercises and provide feedback
			
			Listen students responses and give summary
			
			Check on a sample exercises and provide feedback

• calculatemolarityof asolution from a given information • define the terms equivalent weight, number of equivalents and normality • prepare normal solutions of different substances • calculate normality of a solution from a given information • define molality • prepare molal solutions of different substances calculate molality of a solution from a given information • Inter convert various concentration expressions • explain dilution process • calculate the volume or concentration changes during dilution of solution • prepare a dilute solution from concentrated solution • use stoichiometrically equivalent molar ratios to calculate amounts of reactants and products in a reaction of pure and dissolved substances • explain the relationship	**2.6Solution Stoichiometry** *(3 periods)* • Mole - mass • Mole - volume • Mole - number of particles **2.7Describe reactions in solution** *(1 period)* • Molecular equation • Ionic equation	available chemical in a laboratory. • They should show how to convert among the different units. • Students could explain equivalent weight, number of equivalents, normality and molality • Students should discuss how to prepare normal solution, molal solution and inter conversion of various concentration expressions • Students should explain why stock solutions are usually in high concentrations. • Students should show how a concentrated stock solution is diluted • Students could prepare a 100ml of 0.1 M sucrose from 1M sucrose solution by dilution. • Students should explain the principles of stoichiometry and apply in solutions processes. • Students should explain that if a solution is diluted by simply adding solvent to it, the number of particle of reactants remains the same when doing solution stoichiometry. • Students should calculate amounts of reactants and products in a reaction of pure and dissolved substance. • Students should writethe net ionic equation for a given reaction	Observe and give feedback Check on a sample exercises and provide feedback Listen students responses and give feedback Listen students responses and give feedback Observe students activities and provide feedback Listen students responses and give feedback Listen students responses and give feedback Check on a

between reacting ions, spectator ions, precipitation and solubility • write net ionic equations		• Students should show how writing ionic equations, formulas for weak electrolytes are written in molecular form.	sample exercise and give feedback

Unit 3: Important Inorganic Compounds (21 periods)

Unit outcomes:Students will be able to:

- Classify inorganic compounds on the basis of their composition and/ or their chemistry;
- Discuss types of oxides and their chemical properties;
- Explain the Arrhenius concepts of acids and bases;
- Mention the classification of acids and salts;
- Describe the general properties, preparation and uses of common acids, bases and salts;
- Distinguish the differences between strong and weak acids/ bases; and concentrated and dilute acids/ bases;
- Recognize the corrosive nature of acids and bases, and exercise the necessary precautions in handling and using them;
- Develop skills for identifying acidic, basic and neutral compounds;
- Demonstrate scientific inquiry skills: observing, classifying, comparing and contrasting, inferring, predicting, communicating, measuring, asking questions, interpreting data, drawing conclusion, applying concepts, relating cause and effect and problem solving.

Competencies	***Contents***	***Suggested Activities***	
Students will be able to:	***3.*** **Important Inorganic Compounds**		
• Define inorganic compounds	**3.1Introduction to Inorganic compounds***(1 period)*	Students should identify that the term 'inorganic' is used to describe chemicals that are, in the main, obtained from the ground and are not associated with living things. These chemicals are largely, but not exclusively, compounds of metals.	Give exercise and check students replay
		Students should be asked to tell the names of inorganic compounds with which they are already familiar. Write these on the board. Students should identify that there are different ways of classifying compounds on the basis of their composition and/or their chemistry. For example, they could be classified on the basis of the metals they contain e.g., copper compounds, or on the basis of the groups present e.g., sulphates.	Listen students response and give feedback
• Classify inorganic compounds as oxides, acids, bases and salts		Students should classifyinorganic compounds as oxides, acids, bases and salts.	Check on a sample exercises and give feedback
• Define oxides		Students should explain that oxides are formed when an element	Listen students

Competencies	***Contents***	***Suggested Activities***	
• Classify oxides as acidic, basic, neutral, amphoteric and peroxides • Define acidic oxides • Give examples of acidic oxides • Explain the chemical properties of acidic oxides	**3.2. Oxides** *(3 periods)* • Acidic oxides	combines chemically with the element oxygen. They should identify that oxides themselves can be divided into different groups on the basis of their chemical behaviour and, in the case of peroxides, their structure. Students should discuss that most non-metals form oxides which exhibit acidic properties. They dissolve in water to give acidic solutions; they react with bases and basic oxides. Students could burn a small amount of sulphur or carbon on a deflagrating spoon in a gas jar of oxygen. If water is added to the gaseous product, followed by a few drops of universal indicator, the solution is red (in the case of sulphur) or yellow-orange (in the case of carbon) indicating it is acidic. $S(s) + O_2(g) \rightarrow SO_2(g)$ $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$ $H_2SO_3(aq) \rightleftharpoons 2H^+(aq) + SO_3^{2-}(aq)$	responses and give feedback Observe students activities and give summary
• Define basic oxides • Give examples of basic oxides • Describe the chemical properties of basic oxides	• Basic oxides	Students should describe that most metals form oxides which exhibit basic properties and dissolve in water to give alkaline solutions. They react with acids and acidic oxides. Students could burn a small amount magnesium or calcium on a deflagrating spoon in a gas jar of oxygen. If water is added to the ash followed by a few drops of universal indicator, the solution is blue-purple indicating it is alkaline. $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$	Observe students activities and give summary
• Differentiate basic oxides from acidic oxides by conducting			

Competencies	***Contents***	***Suggested Activities***	
experiments • Compare and contrast acidic and basic oxides • Define amphoteric oxides • Give examples of amphoteric oxides • Discuss the chemical properties of amphoteric oxides • Explain the salt forming nature of acidic oxide, basic oxide and amphoteric oxide • Define neutral oxides • Give examples of neutral oxides • Define peroxides • Give examples of peroxides • Discuss the chemical properties of peroxides	• Amphoteric oxides	$MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(aq)$ $Mg(OH)_2(aq) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$ Students should identify that acidic and basic oxides can be distinguished by their chemical properties. In addition to their effects on indicators acidic oxides react with bases while basic oxides react with acids. Students should be asked to identify that acids and bases are chemical opposites and react together in neutralisation reactions. Explain that: • non-metallic oxides are acidic because they will react with bases • metallic oxides are basic because they react with acids Students could be asked to investigate the chemical reactions of aluminium oxide. Students should react aluminium oxide with a dilute acid, such as hydrochloric acid. $Al_2O_3(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2O(l)$ Students should then react Al_2O_3 with sodium hydroxide solution. $Al_2O_3(s) + 2OH^-(aq) + 3H_2O(l) \rightarrow 2Al(OH)_{4\ aq)}^-$ Students should explain the amphoteric behaviour of Al_2O_3. It reacts both with an acid and a base, hence the name amphoteric oxide. Students should identify that oxides and hydroxides which react with both bases and with acids are described as amphoteric oxides.	Check on a sample exercises and give feedback Observe and give summary Listen students responses and give feedback

Competencies	***Contents***	***Suggested Activities***	
• Differentiate peroxides from other oxides by conducting an experiment	• Neutral oxides • Peroxides	Students could be asked to investigate the amphoteric properties of zinc oxide and of lead oxide. Students should explain that a small number of oxides react neither with acids nor with bases. In other words, they don't show basic or acid properties but are neutral, and therefore described as neutral oxides. Students should recall carbon monoxide and nitrogen monoxide as examples of neutral oxides. Students should identify that a small number of oxides exist in which two oxygen atoms are linked together as –O-O- and that this structure is called a peroxide. Students should demonstrate sodium burning in sufficient oxygen to form sodium peroxide. $2Na(s) + O_2(g) \rightarrow Na_2O_2(s)$ Students should explain that peroxides are powerful oxidising agents and react with the loss of oxygen. There are many organic peroxides which are important activators in polymerisation reactions. Students should be asked to describe the chemistry of hydrogen peroxide, which has the peroxide structure H-O-O-H. Students should be encouraged to show the effect of adding hydrogen peroxide to a coloured dye. The dye is oxidised and the molecule responsible for the colour is destroyed.	Observe students activities and give summary Listen students responses and give summary Observe students actives and give

Competencies	***Contents***	***Suggested Activities***	
			feedback
	3.3. Acids *(6 periods)*		
• Define acids in terms of the concepts of Arrhenius • Give examples of acids based on Arrhenius	• Definitions of acids	Students should be asked to describe the simple definition of an acid as a substance that releases hydrogen ions or protons, H^+, when in solution. Ask students to give some examples of common acids. Students should identify that this definition of an acid, first proposed by Arrhenius, is limited to the chemistry in aqueous solutions.	Listen students responses and give summary
		Demonstrate what happens when ammonia solution and hydrochloric acid are brought together and ask students to consider the reaction that takes place: $NH_3(g) + HCl(g) \rightleftharpoons NH_4Cl(s)$ The hydrogen chloride provides a hydrogen ion or proton but this is not released into aqueous solution since the reaction is carried out between gases.	Observe students activities and give feedback
		Students should identify that acids can be classified according to the number of hydrogen ions or protons that can be released. They should compare hydrochloric acid with sulphuric acid: $HCl(aq) \rightleftharpoons H^+(aq) + Cl^-(aq)$ $H_2SO_4(aq) \rightleftharpoons 2H^+(aq) + SO_4^{2-}(aq)$	Check on a sample exercises and give feedback
• Categorize acids as	• Classification of acids		Check on a

Competencies	***Contents***	***Suggested Activities***	
monoprotic and poly protic based on the number of ionizable(replaceable) hydrogen atom • Group acids as binary and ternary based on the number of elements, they contain	Based on the number of ionizable hydrogen • Classification of acids Based on the number of elements in which it is composed	Students should be asked to differentiate the term 'monoprotic' to describe hydrochloric acid since it has only one replaceable hydrogen atom, and 'diprotic' (or polyprotic) to describe sulphuric acid since it has two (more than one) replaceable hydrogen atoms. Students should explain that acids can be classified as binary or tertiary depending on the number of elements, they contain e.g., hydrochloric acid is a binary acid while sulphuric acid is a ternary acid.	sample exercises and give feedback
• Explain the general properties of acids	• General properties of acids	Students should be asked to perform practical activities that show the properties of acids including: • Effect on common indicators such as litmus, phenolphthalein, methyl red, universal indicator and locally available indicators (e.g. flowers extracts) • Reaction with more reactive metals • Reaction with carbonate and hydrogencarbonates • Reaction with sulphites • Neutralisation reactions with bases/alkalis	Observe students activities and give feedback
• Define strong and weak acids • Differentiate between strong and weak acids • Define concentrated and dilute acids	• Strengths of acids(Strong and weak acids) • Concentrated and	Students should identify that some substances completely dissociate when in aqueous solution. Acids like hydrochloric acid the dissociation is almost complete: $HCl \rightarrow H^+ + Cl^-$ Hydrochloric acid is described as a strong acid because it is almost fully dissociated. Acids like ethanoic acid only a small proportion of molecules	Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	
• Describe the conceptual difference between strong and concentrated acids • Explain the conceptual difference between weak and dilute acids	diluted acids	dissociate: $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ Ethanoic acid is described as a weak acid because it is only partially dissociated. Students should identify that whether an acid is described as strong or weak depends upon the degree which it dissociates and has nothing to do with its concentration.	
		The concentration of an acid is a measure of the number of moles of the acid dissolved in 1 litter and is therefore expressed in mol dm^{-3}.	Check on a sample exercises and give feedback
• Apply the necessary precautions while working with acids	• Precautions in handling acids	Both a strong acid and a weak acid may be concentrated or dilute depending on the number of moles of acid present. Students should demonstrate the corrosive nature of strong acids and some weak acids such as ethanoic acid. Precautions should be taken when handling acids including: • Wearing eye protection • Wiping spillages straight away • Diluting any acid that gets onto clothes • Using a bellows to pipette acid	Observe students activities and give feedback
• Define pH • Describe the pH scale • Identify a given pH-labelled solution as acidic, basic or neutral • Perform activities to determine the pH of	• pH • the relationship between pH and concentration	Students should identify that thepH is negative logarithm of hydrogen (H^+) ion concentration. Students should demonstrate that the pH scale is used to measure acidity and alkalinity. It runs from 0 to 14 and that pH 7 is neutral. The	Observe students activities and give feedback

Competencies	***Contents***	***Suggested Activities***	
some common substances using universal indicators or pH meter • Calculate the pH of a given acidic solution • Calculate the concentration of hydrogen ion from the given information		smaller the pH value the more acidic; the larger the pH value to more alkaline. Students should identify the pH of locally available substances using universal indictor, red and blue litmus paper and a pH meter if available. Students should describe that the pH of an acid is a measure of the concentration of hydrogen ions which is related to its concentration and strength Students should give the mathematical definition of pH = - $\log_{10}[H^+]$. They should identify that pH is a logarithmic scale thus the hydrogen ion concentration of an acid of pH 3 is ten times that of an acid of pH 4. Students should be able to: • Calculate the pH of an acid given its concentration and assuming complete dissociation • Calculate the hydrogen ion concentration of a solution from its pH value	Listen students responses and give feedback Check on a sample exercises and give feedback Check on a sample exercises and give feedback
• Perform activities to investigate some physical properties of acids		Students should be asked to conduct an investigation into the physical properties of acids. These could include: • Effect on acid-alkali indicators • Measuring conductivity • Measuring relative density	Observe students activities and give feedback
• Do activities to investigate some chemical properties of		Students should be asked to conduct an investigation into the chemical properties of acids. These could include:	Observe students activities and give feedback

Competencies	***Contents***	***Suggested Activities***	
acids • Discuss the direct combination of elements, the reaction of acidic oxides with water and formation of volatile acids from non - volatile acids as the three methods of preparation of acids • Carry out simple experiment to prepare acids in laboratory • Describe the uses of the three common laboratory acids.	• Preparation of acids Common uses of HCl, HNO_3, H_2SO_4	• Reaction with a metal e.g., magnesium, zinc, iron • Reaction with metal carbonates and hydrogen carbonates • Reaction with metal oxides and hydroxides Students should be asked differentiatemethods that used to prepare acids. These could include: • The direct synthesis of hydrogen chloride gas by burning hydrogen in chlorine and the subsequent addition of water to form hydrochloric acid, HCl(aq). • The reaction of sulphur dioxide gas with water to form sulphurous acid, H_2SO_3(aq). • The reaction of concentrated sulphuric acid, H_2SO_4 , with sodium nitrate to form nitric acid, HNO_3 Students should be requested to show the preparation of chlorous acid from barium chlorite and sulphuric acid in the laboratory. Students should identify the three common acids used in the laboratory and give some uses of each: • Hydrochloric acid – present in the stomach and needed for digestion; manufacture of aniline dyes; pickling iron to clean it before galvanising and tin plating • Nitric acid – manufacture of explosives, manufacture of nitrate fertilisers • Sulphuric acid – present in car batteries, used to make a variety of other chemicals and products including phosphate fertilisers, detergents, paints and pigments	Check on a sample exercises and give feedback Observe students activities and give feedback Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	
	3.4. Bases *(6 periods)*		
• Define bases in terms of the concepts of Arrhenius	• Definition of bases	• Students should define a base as a substance which dissociates in aqueous solution to release hydroxide ions, OH^-. • e.g. Sodium hydroxide is a base by this definition because it releases OH^- in aqueous solution. Students should identify that an alkali is a base which is soluble in water.	Listen students responses and give feedback
• Give examples of bases based on Arrhenius			
• Discuss the general properties of bases	• General properties of bases	Students should be requested to describe the properties of alkalis/bases including: • Effect on common indicators such as litmus, phenolphthalein, methyl red and universal indicators • Neutralisation reactions with acids Students should identify substances that dissociate in water completely like sodium hydroxide are alkaline: $NaOH \rightarrow Na^+ + OH^-$	Listen students responses and give feedback
• Define strong and weak bases	• Strength of bases (Strong and weak bases)	Sodium hydroxide is described as a strong alkali because it is fully dissociated. Students should be requested to describe an alkali is described as strong or weak depends upon the degree which it dissociates and has nothing to do with its concentration.	
• Distinguish between strong and weak alkalis (soluble bases)	• Concentrated and dilute bases	The concentration of an alkali is a measure of the number of moles of the alkali dissolved in 1 litre and is therefore expressed in mol $liter^{-1}$.	
• Define concentrated and dilute alkalis • Distinguish between		Students should describe both a strong alkali and a weak alkali may be concentrated or dilute depending on the number of moles present.	Listen students responses and

Competencies	***Contents***	***Suggested Activities***	
concentrated and dilute alkalis (soluble bases) • Use the necessary precautions while working with bases	• Precautions in handling bases	Students should identify the corrosive nature of strong alkalis and some weak alkalis such as ammonia solution. Precautions should be taken when handling alkalis including: • Wearing eye protection • Wiping spillages straight away • Diluting any alkali that gets onto clothes • Using a bellows to pipette alkali	give feedback Check on a sample exercises and give feedback
• Define pOH • Show the mathematical relationship between pH and pOH • Calculate the pOH of a given basic solution • Calculate the concentration of hydroxide ion from the given information	• P^{OH} - Relationship between pH and pOH	Students should describe POH is a measure of the concentration of hydroxide ions in an acidic or a basic solution. Students should identify that the pOH scale is used to measure alkalinity or acidity and be given the mathematical definition of pOH = $- \log_{10}[OH^-]$. Students should show that pH and pOH are related mathematically as: $pH + pOH = 14$ Students could attempt to derive this using the ionic product of water, K_w, as follows: In a neutral substance such as distilled water: $K_w = [H^+][OH^-] = 10^{-14}$ $-\log_{10}\{[H^+][OH^-]\} = \log_{10}10^{-14}$ $\{-\log_{10}[H^+]\} + \{-\log_{10}[OH^-]\} = 14$ $pH + pOH = 14$ Students could be asked to determine the pOH values of concentrated	Listen students responses and give feedback Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	
• Carry out activities to investigate some chemical properties of bases • Discuss the reaction of active metals with water, the reaction of basic oxides with water and double displacement reactions as the three methods of preparation of bases • Carry out simple experiments to prepare bases in laboratory • Explain the uses of the two common laboratory bases	• Preparation of bases • Common uses of NaOH and $Ca(OH)_2$	and dilute, weak and strong bases. Students should be asked to: • Calculate the pOH of an alkali given its concentration and assuming complete dissociation • Calculate the hydroxide ion concentration of a solution from its pOH value • Identify bases in their surroundings Students should discuss different methods used to prepare bases. These could include: • The reaction of a reactive metal from Group 1 or Group 2 with water to form the hydroxide. • The reaction of a Group 1 or Group 2 metal oxides with water to form the hydroxide. • Double displacement reactions in which the products of the reaction are a soluble base and an insoluble salt e.g. $K_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow 2\,KOH(aq) + BaSO_4(s)$ Students could prepare the hydroxides of lithium and/or calcium by reacting the metal directly with water. Students could prepare magnesium and/or calcium hydroxide by reacting the metal oxide with water. Students could prepare NaOH or KOH by reaction of a solution of Na or K metal sulphate with barium hydroxide solution.	Check on a sample exercises and give feedback Listen students responses and provide summary Observe students activities and give

Competencies	*Contents*	*Suggested Activities*	
			feedback
		Students should be asked to identify the two common alkalis used in the laboratory and give some uses of each: • Sodium hydroxide – soap, degreasers, various chemicals • Calcium hydroxide – lime water test for carbon dioxide, slaked lime for reducing pH of soil	
	3.5. Salts *(5 periods)*		
• Define salts • Give examples of salts		Students should be requested to explain that a salt is produced when an acid is neutralised by a base: acid + base = salt + water Students should be requested tolist some common salts. They could be able to suggest a possible combination of acid and base to prepare each salt e.g. copper (II) sulphate: sulphuric acid and copper (II) oxide.	Listen students responses and give feedback
• Classify salts as acidic and normal salts	• Classification - Acidic salts - Normal salts - Basic salts	Students should discuss that salts can be classified in three groups: • Acidic salts – are salts in which not all of the hydrogen ions in an acid have been replaced e.g., sodium hydrogensulphate, $NaHSO_4$. Students should understand that when made into an aqueous solution it releases the ions Na^+, H^+, SO_4^{2-}. It releases hydrogen ions hence it is acidic. • Normal salts – are salts in which all of the hydrogen ions in an acid have been replaced e.g. sodium sulphate, Na_2SO_4. • Basic salts- are salts that contain ionizable hydroxide ions e.g Basic zinc chloride, Zn(OH)C1	Monitor the discussion and give summary
• discuss the direct combination of elements, the reaction	• Preparation of salts	Students should be asked to show different methods of preparing	

Competencies	***Contents***	***Suggested Activities***	
of acids with bases, neutralization and the reaction between acids and metals as the methods of salt preparation		salts. These could include: • Metal + acid e.g. calcium, magnesium, aluminium, zinc, iron + dilute hydrochloric/nitric/sulphuric acid Students should identify that metals which are higher in the reactivity series (above calcium) are too vigorous for this method while metals below iron are either too slow or do not react at all. Students should be asked to identify that calcium sulphate is only sparingly soluble so in a reaction with dilute sulphuric acid, calcium tends to become coated with calcium sulphate which inhibits the reaction from proceeding • Metal oxide + acid e.g. transition metal oxides + dilute hydrochloric/nitric/sulphuric acid • Metal hydroxide + acid e.g. Group 1 metal hydroxides + dilute hydrochloric/nitric/sulphuric acid • Metal carbonate + acid e.g. any metal carbonate+dilute hydrochloric/nitric/sulphuricacid • Double decomposition reactions in which two soluble reactants form soluble and an insoluble product which are easily separated e.g., lead nitrate(aq) + sodium iodide solution(aq) = lead iodide(s) + sodium nitrate(aq)	Observe students activities and give feedback Check on a sample exercises and give feedback
• Carry out simple experiment to prepare a salt by neutralization. • List some important salts • Explain the uses of some important salts	• Some important salts and their uses	Students should identify that not every method can be used to make every salt. Students should prepare NaCl from NaOH and HCl and obtain it by evaporation.	Observe and give feedback
• Discuss the properties of salts		Students should be asked to describe the uses of some salts. These	

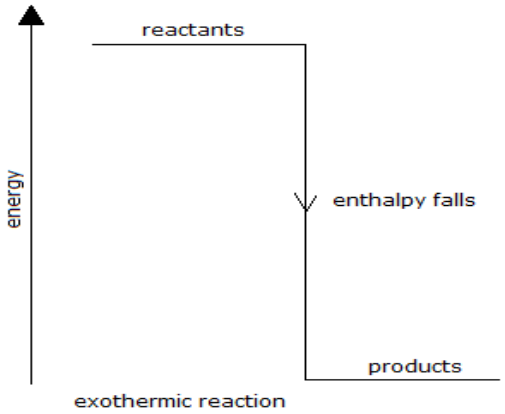
Competencies	***Contents***	***Suggested Activities***	
• Explain the chemical tests of some salts by conducting activities	• Properties of salts • Chemical tests of salts	could include: • Sodium chloride – preparation and preservation of food; raw material for the manufacture of sodium hydroxide and chlorine • Ammonium nitrate – nitrogenous fertiliser • Copper (II) sulphate – Bordeaux mixture and other fungicides • Iron (III) chloride – etching printed circuits • Potassium nitrate – explosives and fertilisers Students should demonstrate the solubility of some salts. They could use their results to derive some simple rules about solubility. Students could be asked to demonstrate the properties of salts which are: • Hygroscopic – absorb water from the atmosphere but remain solid • Deliquescent – absorb so much water from the atmosphere that they form solutions • Efflorescent – lose water to the atmosphere Students could demonstrate that when salts dissolve in water they release ions therefore the solutions conduct electricity. Students could conduct simple tests to detect the presence of specific ions in solution. These could include: • Flame tests – lithium, sodium, potassium, calcium, strontium, barium • Ammonia solution – copper(II) • Sodium hydroxide – iron(II) and iron(III) • Silver nitrate solution – halides • Barium nitrate/chloride solution – sulphates • Dilute acid – carbonates and hydrogencarbonates • Brown ring test – nitrates	Listen students responses and give feedback Observe and give feedback Observe students activities and give feedback

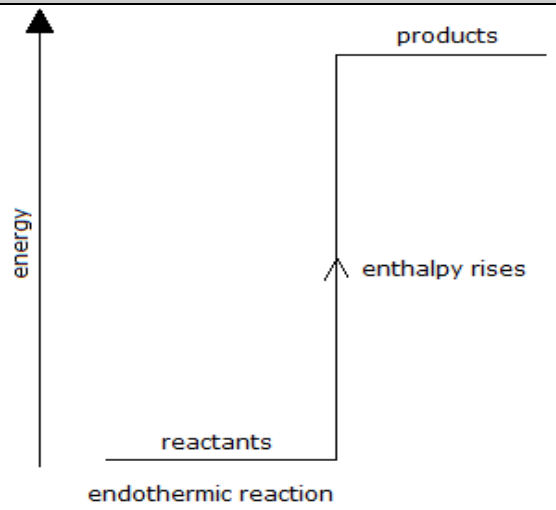
Unit 4: Energy changes in Chemical Reactions *(19 periods)*

Unit outcomes: Students will be able to:

- Describe energy changes in chemical reactions.
- Describe how a chemical reaction produces electric current and how electricity brings about a chemical reaction in electrochemical cells.
- Distinguish the difference between metallic conduction and electrolytic conduction;
- Develop skills in writing the oxidation half-reaction, reduction half-reaction and cell reaction for the electrolysis of molten electrolytes that occur in electrolytic cells;
- List and describe the three types of Voltaic cells;
- Identify the difference between electrolytic cells and voltaic cells;
- Demonstrate scientific inquiry skills: observing, classifying, comparing and contrasting, inferring, predicting, communicating, measuring, asking questions, interpreting data, drawing conclusion, applying concepts, relating cause and effect and problem solving.

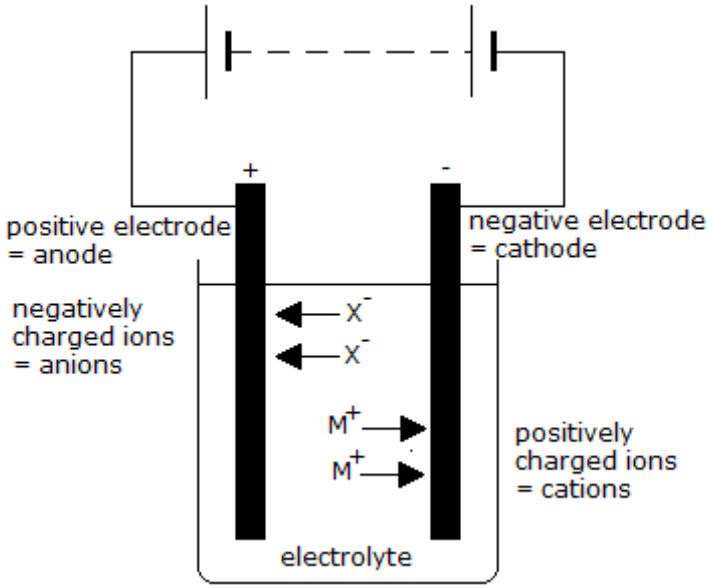
Competencies	*Contents*	*Suggested Activities*	*Assessment*
	4. Energy changes in chemical reactions **4.1 Introduction**		
• Describe energy changes in chemical reactions	***(4 periods)***	Students should explain that changes in energy take place during a chemical reaction. Students should describe enthalpy is a measure of the internal energy of a substance. It is represented by the symbol *H*. The energy change that takes place during a chemical reaction are the result of enthalpy.	Listen students responses and provide feedback
• Define endothermic reaction • Describe endothermic reaction	• Endothermic reaction	Students should explain that in an endothermic reaction: • Heat is taken in from the surroundings • The internal energy of the reactants is less than the internal energy of the products • There is a rise in enthalpy therefore the value of ΔH is positive change in enthalpy and is represented as ΔH.	Listen students responses and give feedback
• Define exothermic reaction • Describe exothermic reaction	• Exothermic reaction	Students should describe as an exothermic reaction: • Heat is given out to the surroundings • The internal energy of the reactants is more than the internal energy of the products • There is a fall in enthalpy therefore the value of ΔH is negative Students should identify that most of the reactions they will see and carry out in the laboratory will be exothermic.	Listen students responses and give feedback Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Elucidate endothermic and exothermic reactions using diagrams	• Energy diagrams for endothermic and exothermic reactions	Students should be requested to draw energy diagrams to represent exothermic and endothermic reactions. These have the general form:  $H_r > H_P \therefore \Delta H$ is negative ($\Delta H < 0$) H_r - heat content of reactants H_P - heat content of products	Observe students activities and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Do simple experiment to demonstrate exothermic and endothermic reactions		 $H_P > H_r \therefore \Delta H$ is positive ($\Delta H > O$) Students should be asked to carry out some exothermic and endothermic reactions to identify heat is given out or taken in either by direct observation or by measuring temperature rise/fall with a thermometer. These could include: Exothermic • Burning gas • Adding water to anhydrous copper (II) sulphate • Adding a few drops of concentrated sulphuric acid to water • Mixing dilute hydrochloric acid and sodium hydroxide solution Endothermic • Adding solid ammonium nitrate to water • Adding solid potassium nitrate to water	Observe students activity and give feedback Monitor the discussion and give

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Discuss the importance of chemical changes in the production of new substances and energy	Importance of chemical changes **4.2 Energy changes in electrochemistry (8** *periods*	Students should discuss about the importance of the energy released in some exothermic reactions. These should include: • Combustion of fuels • Oxidation of glucose during cell respiration	feedback
• Describe electrochemistry • Define electrical conductivity • Explain metallic conductivity • Explain electrolytic conductivity • Differentiate between metallic conduction and electrolytic conduction • Distinguish between strong and weak electrolytes • use conductivity apparatus to test conductivity of substances • Define the term electrolysis • Define the terms electrode, anode cathode, electrolyte, anion, and cation	• **Electrochemistry** Electrical conductivity • Metallic conductivity • Electrolytic conductivity	Students should describe that electrochemistry is concerned with bringing about chemical change using an electric current or generating electrical energy from chemical reactions. Students should explain that both metals and aqueous electrolytic solutions conduct electricity but that the process is different in each case. Students should describe that in metallic conductivity: • Metallic structure can be described as matrix of positive ions in a sea of mobile electrons • Metals contain delocalised valence electrons which are able to move • Electric charge is carried by electrons Students should check the ability of different materials to conduct electricity. Students could be requested to relate the ability of graphite, a non-metal, to conduct electricity to the delocalised electrons contained within its layered structure.	Listen students responses and give feedback Observe students activities and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Describe electrolytic cell	**4.3. Electrolysis *(3 periods)*** • Electrolytic cell • Electrolysis of molten electrolytes	Students should describe that in electrolytic conductivity: • The electrolyte contains ions • The ions are able to move in the solution • Electric charge is carried by ions Students should explain that ionic compounds are composed of ions but their ions are not mobile when the compound exists as a solid – and this is why ionic solids do not conduct an electric current. Students should identify the ability of different soluble compounds to conduct electricity. These could include: • Ionic compounds such as salt Organic compounds such as glucose and sucrose This could be asked to do simple experiments using a simple circuit composed of three cells and a lamp. Students should define that electrolysis is the process of bringing about chemical change using an electric current. They should describe terminologies such as: • Anode • Anions • Cathode • Cations • Electrolyte Students should provide schematic representation of electrolytic cells and label their components	Listen students responses and give feedback Check on a sample exercises and give feedback Observe students activities and give feedback Listen students responses and give feedback Observe students activities and give

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Draw labelled diagram of an electrolytic cell • Define the terms' half-reaction and cell reaction		 Students should explain that the ability of an electrolyte to conduct an electric current is determined by the concentration of ions. • Strong electrolyte – high concentration of ions e.g. very soluble ionic compound • Weak electrolyte – low concentration of ions e.g. sparingly soluble ionic compound Students should be asked to draw an electrolytic cell and label: • Power source (must be d.c.) • Electrolyte • Anode • Cathode	feedback Listen students responses and give feedback Observe students activities and give feedback Monitor the

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Write the oxidation half-reaction, reduction half reaction and cell reaction for the electrolysis of molten or fused electrolytes • Perform an activity to show electrolysis of molten electrolytes		Students should discuss that during electrolysis: • Negatively charged ions or anions are attracted to the positive electrode or anode • The anions lose electrons to form atoms (that combine to form molecules) • The anions are therefore oxidised • The reaction at the anode can be shown by a half equation • Positively charged ions or cations are attracted to the negative electrode or cathode • The cations gain electrons to form atoms • The cations are therefore reduced • The reaction at the cathode can be shown by a half equation Students should be requested to conduct the electrolysis of molten lead bromide using graphite electrodes. Students could: • Observe bromine given off at the anode • Write a half equation for the reaction at the anode $2Br^- \rightarrow Br_2 + 2e^-$ • Identify the reaction at the anode as an oxidation reaction because it involves the loss of electrons • Observe lead produced at the cathode • Write a half equation for the reaction at the cathode $Pb^{2+} + 2e^- \rightarrow Pb$ • Identify the reaction at the cathode as a reduction reaction because it involves the gain of electrons Students should be requested to consolidate their understanding of the term's oxidation and reduction in terms of electron loss and	discussion and give feedback Observe students activities and give feedback Listen students responses and give feedback

Competencies	*Contents*	*Suggested Activities*	*Assessment*
• Construct a simple cell using strips of zinc, copper, $ZnSO_4$ and $CuSO_4$ solutions • mention different types of voltaic cells • Describe how voltaic cells can be used to make commercially useful batteries • Distinguish between voltaic cell and an electrolytic cell • Describe voltaic cell	**4.4 Electrochemical cells (*4 period)*** Galvanic cells (voltaic cells) Primary cells and secondary cells	gain. They should identify that equal number of electrons are lost at the anode and gained at the cathode, and since electrolysis overall is a redox reaction and oxidation or reduction cannot occur in isolation – if something is oxidised something else must be reduced. • Students should make a simple cell by inserting pieces of different metals into a lemon or lime. This could be extended by investigating which metals give the greatest voltage and which the least they related to the reactivity series • Students should explain that early cells consisted of metal rods suspended in electrolyte solutions. They are sometimes referred to as wet cells. Student could research to find out more about: - The wet Leclanché cell - The Daniell cell Students could discuss the practical problems of using wet cells and why dry cells were developed • Students should draw and label the structure of a dry Leclanché cell • Students should identify that in a dry cell: • Oxidation occurs at the negative electrode (zinc) with the reaction $Zn(s) \rightarrow Zn^{2+} + 2e^-$ • Reduction occurs at the positive electrode (carbon) with the reaction $2\ 2NH_4 + (aq) + 2MnO_2 + 2e^- \rightarrow Mn_2O_3(s) + 2NH_3(aq) + H_2O(l)$ When the cell is connected in a circuit	Observe students' performance and give feedback Listen students' responses and give summary Check students' performance and give feedback Check students' responses and give

Competencies	***Contents***	***Suggested Activities***	***Assessment***
		electron are pumped from the negative electrode to the positive electrode • Students should explain the terms 'conventional current' and 'actual current' and the reason for them • Students should identify that dry cells are described as primary cells because they cannot be recharged. Once the chemicals in the cell are exhausted no electricity flows and the cells are replaced • Students should compare this with a secondary cell which can be recharged when it becomes exhausted. They also identify that a car battery can be used as an example of a secondary cell.	summary

Unit 5: Metals and non-metals (13 periods)

Unit outcomes: Students will be able to:

- Explain the renewable and non-renewable natural resources and appreciate their importance in industry as raw materials;
- Describe the extraction, chemical properties and uses of aluminium, iron, copper, nitrogen, phosphorus, oxygen, sulphur, and chlorine;
- Describe the production and chemical properties of nitrogen, phosphorus, oxygen, sulphur and chlorine;
- Demonstrate scientific inquiry skills: observing, classifying, communicating, and asking questions, applying concepts and problem solving.

Competencies	***Contents***	***Suggested Activities***	***Assessments***
Students will be able to:	***5. Metals and non-metals***		
	5.1 Introduction *(1 period)*		
• Define natural resources • List natural resources	• Definition of natural resources • Classification of natural resources	Students should describe that natural resources are materials that are available on Earth for people to use. Students should make a list of natural resources. This could include: • Stone, metal ores, soil, wood, air, food crops, crude oil, natural gas, coal, fibres (e.g. wool and cotton)	Listen students responses and give feedback
	• Importance of natural resources for industry	Students should discuss that natural resources provide many important raw materials which are the starting materials for industrial processes.	Monitor the discussion and summarize
	5.2 Production of some important metals and non-metals *(12 periods)*		
• Outline the extraction		Students should discuss about the extraction of	Monitor the discussion and

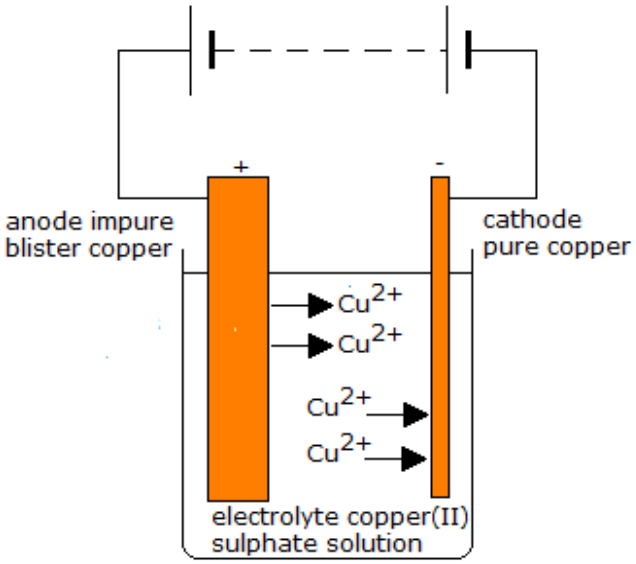
Competencies	***Contents***	***Suggested Activities***	***Assessments***
of aluminium by the Hall process	**Aluminium**	aluminium. This should include:	summarize
	- Extraction	• The main ore of aluminium is bauxite (Al_2O_3) • Aluminium is a reactive metal and cannot be extracted simply by heating the bauxite • Aluminium is extracted by electrolysis using the Hall cell • Bauxite is first purified and converted to alumina $Al(OH)_3$ and then decomposing the alumina back to aluminium oxide • Alumina is dissolved in molten cryolite in the electrolytic cell: the reactions at the graphite electrodes are: Anode: $6O^{2-} \rightarrow 3O_2 + 12e^-$ Cathode: $4Al^{3+} + 12e^- \rightarrow 4Al$ • Under the conditions in the cell the anode is gradually oxidised to carbon dioxide and must be replaced periodically • Molten aluminium is siphoned off or tapped off from the bottom of the cell	
• Describe the main physical and chemical properties of aluminium		Students should describe the physical properties of aluminium	Listen students responses and give summary
	- chemical properties	Students should describe the chemical properties of aluminium. These should include: • Aluminium is a reactive metal and rapidly reacts with oxygen from the air to form a layer of aluminium oxide. This layer of aluminium oxide inhibits the reaction of aluminium thus aluminium sometimes appears less reactive that its position in the reactivity series would suggest. This can be removed with	

Competencies	***Contents***	***Suggested Activities***	***Assessments***
		mercury(II) chloride solution. Freshly exposed aluminium reacts rapidly with oxygen from the air to form aluminium oxide. $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$ • Aluminium reacts with dilute acids to form salts e.g. $2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$ • Aluminium burns in chlorine gas to form aluminium chloride. $2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$ • Aluminium reacts with sodium hydroxide solution $2Al(s) + 2NaOH(aq) + 6H_2O(l) \rightarrow 2NaAl(OH)_4(aq) + 3H_2(g)$	
• Describe the uses of aluminium	- Uses	Students should give examples of aluminium made materials in their surroundings Students should discuss about the uses of aluminium. These should include • The manufacture of light alloys e.g. duralumin • The construction of air crafts , ships and cars • The manufacture of household utensils • Window frames and roofing sheets • Packing material the food industry	Monitor the discussion and summarize
• Outline the extraction of iron by the blast furnace	• **Iron** - Extraction	Students discuss in group about the extraction of iron. This should include: • The main ores of iron are haematite (Fe_2O_3) and magnetite (Fe_3O_4) • Iron is less reactive than aluminium and can be	Monitor the discussion observe students' participation in the

Competencies	***Contents***	***Suggested Activities***	***Assessments***
• Briefly describe conversion of pig iron to steel • Describe wrought iron	- Conversion of pig iron to steel - Wrought iron	extracted by heating the ore with a reducing agent. • Iron is extracted in a blast furnace. A mixture of iron ore, coke and limestone are heated together and air is blown through them • Coke is essentially carbon and is oxidised to carbon dioxide. The carbon dioxide then reacts with excess carbon and is reduced to carbon monoxide $C + O_2 \rightarrow CO_2$ $CO_2 + C \rightarrow 2CO$ • Carbon monoxide is the main reducing agent in the blast furnace and reduces the iron ore to iron $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ • The heat decomposes the limestone to calcium oxide and carbon dioxide $CaCO_3 \rightarrow CaO + CO_2$ • Calcium oxide reacts with acidic impurities such as silicon dioxide to form a slag. This protects the lining of the furnace from damage $CaO + SiO_2 \rightarrow CaSiO_3$ • Molten iron falls to the bottom of the furnace and is tapped off • Slag floats on top of the molten iron and is scraped off and used as a foundation for road building • Students should be given a project to construct a model which shows the blast furnace form locally available materials. Students should explain the conversion of pig iron to steel. The iron obtained from blast furnace (called pig iron) contains impurities like carbon that make it brittle. Steel can be made by blowing oxygen into molten iron to	group activities and provide feedback Record students' performance and provide feedback

Competencies	***Contents***	***Suggested Activities***	***Assessments***
• Describe the main physical and chemical properties of iron	- Physical properties - Chemical properties	oxidize impurities and decrease the amount of carbon content. Students should identify that wrought iron is the purest form of iron with very low carbon content and other impurities. Students should describe the physical properties of iron. Students should explain about the chemical properties of iron. These should include: • Iron reacts with dilute acids to form salts e.g. $Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$ • Iron rusts in the presence of air and moisture to form a hydrated iron oxide • Iron is a transition metal and has two common oxidation states Fe(II) and Fe(III) • Iron(II) and iron(III) compounds are coloured • Solutions of some iron(II) compounds are rapidly oxidised to the corresponding iron(III) compounds by air • Heated iron reacts with hydrogen chloride gas. $Fe(s) + 2HCl(g) \rightarrow FeCl_2(s) + H_2(g)$ • Heated iron reacts with chlorine gas. $2Fe(s) + 3Cl_2(g) \rightarrow 2FeCl_3(s)$ • Iron will displace ions of less reactive metals from solutions of their salts $Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$	Record students' performance and provide feedback

Competencies	***Contents***	***Suggested Activities***	***Assessments***
• Describe the uses of iron	- Uses	Students should describe the use of iron. These could include: • as pig iron to make items like domestic boilers, castings and mouldings • as wrought iron to ornamental gates, door knockers, etc. • Manufacture of alloys, e.g. Carbon steels and alloy steels.	Record students' performance and provide feedback
• Outline the extraction of copper	• **Copper** - Extraction	Students should discuss in group about the extraction of copper. This should include: • Copper is an unreactive metal and can be found in the ground as native metal, but is more often found as sulphide ores such as bornite (Cu_5FeS_4), chalcopyrite ($CuFeS_2$) and chalcocite (Cu_2S) • Copper ore can be reduced to copper by roasting in air. The oxygen combines with the sulphur to form sulphur dioxide $Cu_2S(s) + O_2(g) \rightarrow 2Cu(s) + SO_2(g)$ The copper obtained by roasting is called blister copper and is too impure for use. • Blister copper is further purified by electrolysis	Monitor the discussion, record students' performance and provide feedback

Competencies	***Contents***	***Suggested Activities***	***Assessments***
• Describe the main chemical properties of copper	- Chemical properties	 Anode: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ Cathode: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ Students should describe the physical properties of copper Students should explain about the chemical properties of copper. These should include: Copper reacts with oxygen forming copper oxide $2Cu(s) + O_2(g) \rightarrow 2CuO(s)$ • Over a period of time in damp air, copper turns green due to the formation of verdigris, a basic carbonate	Record students' performance and provide feedback

Competencies	***Contents***	***Suggested Activities***	***Assessments***
• Describe the uses of copper • Define alloys and give examples • Outline the production of nitrogen	- Uses • **Nitrogen** - Production	($CuCO_3.Cu(OH)_2$) Copper is a transition metal and has two common oxidation states Cu(I) and Cu(II) Copper (II) compounds are coloured • Copper does not react with dilute acids. But it reacts with dilute and concentrated HNO_3 and hot concentrated H_2SO_4 Students should explain about the uses of copper. These could include: • Manufacture of alloys • Electrical conductor Students should give bronze, brass, solder and steel as examples of alloys Students should discuss in group about the production of nitrogen. This should include: • Nitrogen makes up about 80% by volume of air • Nitrogen is obtained by the fractional distillation of liquid air • Water vapour and carbon dioxide are removed from air and what remains is compressed and cooled to form liquid air • The temperature of the liquid air is allowed to rise and the gases in air boil off at different temperatures; nitrogen at -196 °C, argon at - 186° C and oxygen at -183 °C. Students should describe the physical properties of	Record students' performance and provide feedback Monitor the group discussion, record students' performance and provide feedback Monitor the discussion, record students'

Competencies	***Contents***	***Suggested Activities***	***Assessments***
• Describe the main chemical properties of nitrogen	- Chemical properties	nitrogen Students should discuss in group about the chemical properties of nitrogen. These should include: • Nitrogen is relatively inert • When heated with reactive metals in Groups 1and 2, nitrogen reacts to form nitrides $3Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)$ • Nitrogen reacts with oxygen to form a number of different oxides: N_2O, NO, NO_2 • In the Haber process nitrogen and hydrogen combine to form ammonia $N_2(g) + 2H_2(g) \rightarrow 2NH_3(g)$	performance and provide feedback Monitor the discussion, record students' performance and provide feedback
• Outline the production of phosphorous	• **Phosphorous** - Production	Students should discuss in group about the production of phosphorus. This should include: • Phosphorus has two common allotropes: white phosphorus and red phosphorus • White phosphorus can be made in a number of ways including heating calcium phosphate in an electric furnace in the presence of carbon and silica. White phosphorus given off as vapour and collected under phosphoric acid. • Red phosphorus can be made by heating white phosphorus to 250 °C or by leaving it in sunlight	
• Describe the main chemical properties of phosphorus		Students should give the physical properties of phosphorus.	Record students' performance and

Competencies	***Contents***	***Suggested Activities***	***Assessments***
	- Chemical properties	Students should describe about the chemical properties of phosphorus. These should include: • Phosphorus reacts with oxygen to form phosphorus oxides, P_2O_3 and P_2O_5, e.g. phosphorus(V) oxide $P_4(s) + 5O_2(g) \rightarrow 2P_2O_5(s)$ • These oxides dissolve in water to form acids e.g. phosphoric(V) acid $P_2O_5(s) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$ • Phosphorus reacts with chlorine to form phosphorous chlorides, PCl_3 and PCl_5, e.g. phosphorus(V) chloride • $P_4(s) + 10Cl_2(g) \rightarrow 4PCl_5(s)$	provide feedback Monitor the discussion, record students' performance and provide feedback
• Outline the production of oxygen • Describe the main	• **Oxygen** - Production Chemical properties	Students should discuss about the production of oxygen. This should include: • Oxygen makes up about 20% by volume of air • oxygen is obtained by the fractional distillation of liquid air • Water vapour and carbon dioxide are removed from air and what remains is compressed and cooled to form liquid air • The temperature of the liquid air is allowed to rise and the gases in air boil off at different temperatures; nitrogen at -196 °C, argon at - 186°C and oxygen at -183 °C. Students should know about the chemical properties of	

Competencies	***Contents***	***Suggested Activities***	***Assessments***
chemical properties of oxygen		oxygen. These should include: • Oxygen is relatively reactive • Oxygen combines with metals to form basic oxides $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ • Oxygen combines with non-metals to form acidic oxides $S(s) + O_2(g) \rightarrow SO_2(g)$ • Oxygen is required for combustion $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$	Monitor the discussion, record students' performance and provide feedback
• Outline the production of sulphur	• **Sulphur** - Production	Students should discuss in group about the extraction of sulphur. This should include: • Sulphur exists in the ground in elemental form • Elemental sulphur is extracted by the Frasch process. Hot water is pumped underground under high pressure and melts the sulphur. The molten sulphur is then brought to the surface • About half of the sulphur needed by industry is obtained as a waste product of other industrial processes. These are mainly from the removal of hydrogen sulphide from natural gas and refined crude oil, and the removal of sulphur dioxide obtained by roasting metal sulphide ores. • Using sulphur produced by other industries reduces the demand on natural resources and reduces atmospheric pollution and acid rain	
• Describe the main chemical properties of sulphur	- Chemical properties	Students should describe the physical properties of	

Competencies	***Contents***	***Suggested Activities***	***Assessments***
• Outline the production of chlorine	• **Chlorine** - Production	sulphur Students should describe about the chemical properties of sulphur. These should include: • When heated with metals, sulphur combines to give metal sulphides $Fe(s) + S(s) \rightarrow FeS(s)$ • Sulphur reacts with oxygen to form two different oxides: SO_2 and SO_3 • Sulphur is the raw product from which sulphuric acid is made: $S(s) + O_2(g) \rightarrow SO_2(g)$ $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ $H_2SO_4(l) + SO_3(g) \rightarrow H_2S_2O_7(l)$ $H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$ Students should discuss in group about the production of chlorine. This should include: • Chlorine is obtained by the electrolysis of concentrated sodium chloride solution or brine. Sodium hydroxide solution is produced at the same time Ions in solution Na^+, H^+, Cl^-, OH^- Anode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$	Monitor the discussion, record students' performance and provide feedback

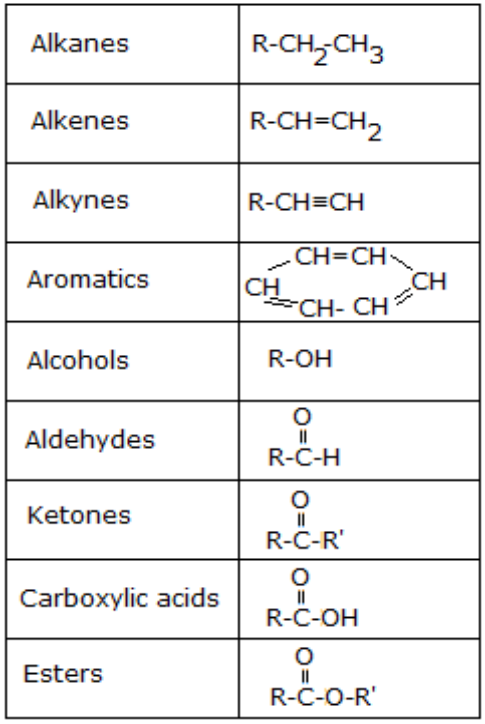
Competencies	***Contents***	***Suggested Activities***	***Assessments***
• Describe the chemical properties of chlorine	- Chemical properties	Cathode: $2H^+ + 2e^- \rightarrow H_2(g)$ Ions remaining in solution: Na^+, OH^- • Chlorine and sodium hydroxide solution must be kept apart as they react together $NaOH(aq) + Cl_2(g) \rightarrow NaOCl(aq) + HCl(aq)$ Students should describethe physical properties of chlorine Students should describe about the chemical properties of chlorine. These should include: • Chlorine is a powerful oxidising agent • Chlorine reacts with heated metals to form chlorides $2Fe(s) + 3Cl_2(g) \rightarrow 2FeCl_3(s)$ • Chlorine reacts with hydrogen to form hydrogen chloride $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ • Chlorine will displace less reactive halide ions from solutions of their compounds $Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$ • Chlorine dissolves in water to give an acidic solution $H_2O(l) + Cl_2(g) \rightarrow HCl(aq) + HOCl(aq)$ • Chlorine and chlorine water will bleach coloured material	

Unit 6: Hydrocarbons and their Natural sources (21 periods)

Unit outcomes: Students will be able to:

- Discuss the historical development of organic chemistry and classification of organic compounds;
- Write the general formulas of alkanes, alkenes and alkynes
- Develop skills in naming and writing the molecular and structural formulas of simple alkanes, branched chain alkanes, simple alkenes, branched chain alkenes and simple alkynes
- Explain isomerism and draw the possible isomers of alkanes and alkenes;
- Explain the physical and chemical properties; and general methods of preparation of alkanes, alkenes, alkynes, benzene and alcohols
- List the major natural sources of hydrocarbons;
- Demonstrate scientific inquiry skills: observing, classifying, communicating, measuring, asking questions, interpreting data, drawing conclusions, applying concepts, predicting and problem solving.

Competencies	*Contents*	*Suggested Activities*	*Assessment*
Students will be able to:	***6. Hydrocarbons and their natural sources***		
	6.1 Introduction *(1 period)*		
• Narrate the historical development of organic chemistry.	• History of organic chemistry	Students should describe that chemicals found in and derived from living things, both animals and plants, were once thought to contain a life force, the 'force vitals', which was absent in chemicals obtained from the ground.	Let students give their reflections and give summary
• Classify organic compounds	• Classification of organic compounds	On this basis, all chemicals were divided into two groups: • Organic chemicals • Inorganic chemicals Students should identify that, although the theory of life force has long since been discarded after Wohler's synthesis of Urea, this classification is still used but the definition of organic chemistry has changed. Organic chemistry is now described as the chemistry of carbon with the exception of the oxides of carbon, carbonates and hydrogen carbonates.	
• Define the term functional group		Students should explain that organic compounds are classified into groups on the basis of a functional group. It is the functional group in a molecule that determines much of the chemistry of a compound. The functional groups of organic	Listen students responses and

Competencies	Contents	Suggested Activities	Assessment
		chemicals studied in this unit could be given as a table.	give feedback
			
	6.2 Saturated hydrocarbons (alkanes) (*9 periods)*		
• Define hydrocarbon		Students should define the term hydrocarbon is used to describe organic chemicals that contain hydrogen and carbon only.	Listen students responses and give feedback

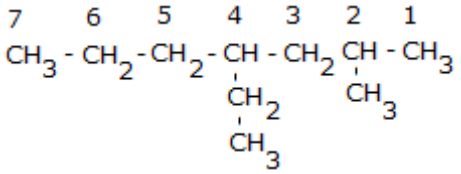
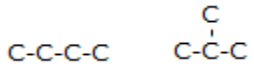
Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Define saturated hydrocarbon		• Compounds that contain only carbon-carbon single bonds, the alkanes to be studied now, are described as saturated hydrocarbons. • Compounds that contain carbon-carbon double or triple bonds, the alkenes, alkynes and aromatic compounds to be studied later are described as unsaturated hydrocarbons.	
• Define homologous series • Drive the general formula of alkanes and cycloalkanes from based on the number of hydrogen and carbon	• Homologous series	Students should identify that a series of compounds that differ by a certain same group are called a homologous series. The alkanes are a homologous series which have the general formula C_nH_{2n+2}. Whereas, cycloalkanes have the general formula of C_nH_{2n} .	Check on a sample exercises and give feedback
• Write the first ten members of alkanes and cycloalkanes homologous series • Write the molecular formulas of alkanes from the given numbers of carbon atom		Students should be requested to apply the general formula to generate the chemical formulas of the first ten alkanes in the series. For example: n=1, CH_4, n=2, C_2H_6 etc. Whereas, for cycloalkanes, when n= 3; C_3H_6, n=4 C_4H_8, etc.	Listen students responses and give feedback
• Explain the physical properties of alkanes	• Physical properties	Students should explain that there are forces of attraction between molecules in alkanes (van der Waals' forces). As the size of the molecule increases so do the forces. At room temperature: • Alkanes up to and including C_4 are gases • Alkanes from $C_5 – C_{17}$ are liquids • Alkanes C_{18} and above are solids	
• Apply IUPAC rules to name straight and branched chain alkanes.	• Nomenclature	Students should discuss that the name of an organic chemical is derived from: • a prefix indicating the number of carbons present	Monitor the discussion and give feedback

<table>
<tr><th>Competencies</th><th>Contents</th><th>Suggested Activities</th><th>Assessment</th></tr>
<tr>
<td>• Write the structural formulas of the first ten alkanes</td>
<td>• Isomerism</td>
<td>
• a suffix indicating the functional group present
Students should encouraged to learn the prefixes for compounds containing up to ten carbon atoms as these are widely used in organic chemistry.
<table>
<tr><th>Prefix</th><th>Number of carbon atoms</th><th>Prefix</th><th>Numbe</th></tr>
<tr><td>Meth</td><td>1</td><td>hex</td><td>6</td></tr>
<tr><td>Eth</td><td>2</td><td>hept</td><td>7</td></tr>
<tr><td>Prop</td><td>3</td><td>oct</td><td>8</td></tr>
<tr><td>But</td><td>4</td><td>non</td><td>9</td></tr>
<tr><td>Pent</td><td>5</td><td>dec</td><td>10</td></tr>
</table>
Students should be asked to use the suffix ‘ane’ to generate the names of the first ten alkanes e.g. meth + ane = methane, eth + ane= ethane, etc.

Students could give structures and name the first ten alkanes in the series.

Students should describe the principles of naming branched chain alkanes:

• identify the longest possible carbon chain which gives the base name
• Number the carbon atoms in the longest carbon chain. Any side groups are on the lowest possible numbered carbon
• name the side chains on the basis of the prefix which
</td>
<td>Check students’ performances and give feedback</td>
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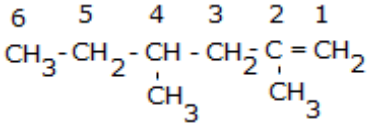
Competencies	*Contents*	*Suggested Activities*	*Assessment*
• Define isomerism as the way how compounds having the same formula differ in the way their atoms are arranged • Define structural isomerism • Draw the possible structural isomers for C_4H_{10}, C_5H_{12} and C_6H_{14}.		indicates the number of carbon atoms, followed by the suffix –yl • combine the side chains and the base name to give the name of the compound as one word Students should work through an example with the help of the teacher.  • The longest carbon chain contains 7 carbon atoms therefore it is a heptane • The carbon chain is numbered from right to left to ensure the numbers of the carbon atoms which have groups attached are as low as possible • There is a methyl group on carbon 2 • There is an ethyl group on carbon 4 Combining this information gives 4-ethyl 2-methylheptane Students should identify that the first three members of alkanes- CH_4 ,C_2H_6 and C_3H_8 etchave only one possible arrangement for their structures. Students should show the possible isomers of butane, C_4H_{10}. They should appreciate that it is easier simply to draw the carbon skeletons and omit the hydrogen atoms. 	Check students' performances and give feedback

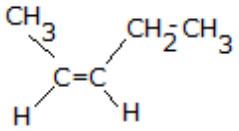
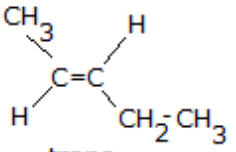
Competencies	***Contents***	***Suggested Activities***	***Assessment***
		Students should show that when the number of carbons in an alkane reaches four or more there are different ways of arranging them in a molecule. This is called isomerism. The isomers have the same chemical formula but different structures and different physical properties such as melting point and boiling point. Students should show by drawing as many possible different structures as they can for pentane, C_5H_{12} (3 isomers) and hexane, C_6H_{14} (5 isomers). Students could practice this technique by naming the different isomers of pentane and hexane.	Check students' performances and give feedback
• Describe the general methods for preparation of alkanes in a laboratory • Synthesis methane in a laboratory by decarboxylation method	• Preparation	Students should should that crude oil is a mixture of many different alkanes and that industrially, alkanes are obtained by the refining of crude oil. In the laboratory alkanes can be made by a number of different routes including: • The hydrogenation of alkenes $R\text{-}CH{=}CH_2 + H_2 \rightarrow R\text{-}CH_2\text{-}CH_3$ • The Wurtz synthesis using halogenated hydrocarbons and sodium $2R\text{-}Br + 2Na \rightarrow R\text{-}R + 2NaBr$ • The decarboxylation of the sodium salt of a carboxylic acid $RCOONa + NaOH \rightarrow Na_2CO_3 + R\text{-}H$ Student should appreciate evolution of methane gas in	

Competencies	***Contents***	***Suggested Activities***	***Assessment***
		marshy areas. Students should be requested to synthesize methane by the decarboxylation of sodium ethanoate. Students should be asked to produce methane on a small scale by the fermentation of cow dung. They should identify the significance of methane made in this way, as the main component of biogas, and how it provides a renewable source of energy	Check students' performances and give feedback
• Carryout a project work to produce biogas from cow dung			
• Explain the chemical properties of alkanes	• Chemical properties	Students should describe that alkanes are generally considered unreactive chemicals. • Like all hydrocarbons, alkanes burn in air to give carbon dioxide and water. In limited supplies of air some carbon monoxide is also formed. • Alkanes react with chlorine in the presence of sunlight to produce chloroalkanes. This is an example of a free radical reaction.	Listen students responses and give feedback
	6.3 Unsaturated hydrocarbons – alkenes and alkynes *(9 periods)* • Homologous series		
• Define unsaturated hydrocarbons • Define alkenes		Students should give the definition of an unsaturated hydrocarbon from the previous section in terms of the presence of carbon-carbon double or triple bonds. Students identify that alkenes are a homologous series of	Let students give their reflections and provide feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Write the general formula of alkenes • Write the molecular formula first nine homologous series of alkenes	• Nomenclature	unsaturated hydrocarbons: • Alkenes contain the functional group C=C • The general formula for alkenes is C_nH_{2n} • The suffix used for alkenes is 'ene' Students should be asked to write the molecular formulas of the first nine alkenes in the series. Students could use the prefixes given in the previous section together with the suffix 'ene' to name the first nine alkenes in the series.	Check students' performances and give feedback
• Define alkynes • Write the general formula of alkynes • Write the molecular formula first nine homologous series of alkynes		Students should describe that alkynes are also a homologous series of unsaturated hydrocarbons: • Alkynes contain the functional group C≡C • The general formula for alkynes is C_nH_{2n-2} • The suffix used for alkynes is 'yne' Students should be given a chance to write the molecular formulas of the first nine alkynes in the series. Students could be asked to use the prefixes given in the previous section together with the suffix 'yne' to name the first nine alkynes in the series.	Listen students responses and give feedback Check students' performances and give feedback
• Write the molecular formulas of alkenes and alkynes from the given number of carbon atoms		Students should be able to write the molecular formulas of alkenes and alkynes provided with number of carbon atoms.	
• Describe the physical properties of alkenes and alkynes	• Physical properties	Students should describe that, as was the case with alkanes, there are forces of attraction between the molecules in both alkenes and alkynes. Those with small molecules are gases at room temperature but as the carbon chain increases in size	Listen students responses and

Competencies	***Contents***	***Suggested Activities***	***Assessment***
		the attractive forces also increase giving higher melting points and boiling points. Alkenes and alkynes with large molecules are liquids and larger still, are solids.	give feedback
• Write the structural formulas alkenes and alkynes up to nine carbon atoms.	• Isomerism	Students should identify that within the carbon chain of an alkene, a carbon-carbon double bond might be between any pair of adjacent carbon atoms. The same is true of the carbon-carbon triple bond in alkynes. In order to differentiate between two molecules with the same formula but in which the carbon-carbon double or triple bond is in a different position, we: • number the carbon atoms in such a way that the carbon atoms joined by the double or triple bond have the lowest number • give the number of the first carbon atom involved in the bond Students should consider some examples. C-C-C≡C C-C≡C-C but -1-yne but-2-yne (1-butyne) (2-butyne) C-C-C-C-C=C C-C-C-C=C-C C-C-C=C-C-C Hex-1-ene hex-2-ene hex-3-ene (1-hex ene) (2-hex ene) (3-hex ene)	Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Use IUPAC rules to name straight and branched chain alkenes and alkynes. • Write possible structural isomers for C_4H_8 and		Students could draw and name different straight chain alkenes and alkynes up to nine carbon atoms. Students should identify that the rules given for naming branched chain alkenes and alkynes are the same as those for alkanes with the additional requirement of identifying the position of the carbon-carbon double or triple bond. Students should work through an example with the help of the teacher.  • The longest carbon chain contains 6 carbon atoms therefore it is a hexene • The carbon chain is numbered from right to left to ensure the numbers of the carbon atoms which have groups attached are as low as possible • The carbon-carbon double bond is between carbons 1 and 2 • There are methyl groups on carbons 2 and 4 Combining this information gives 2,4-dimethylhex-1-ene. Students could be asked to practice this technique by naming the same other branched chain alkenes. Students should show that isomers of C_5H_{10} exist because the carbon-carbon double bond can be in two different positions, giving pent-1-ene and pent-2-ene. Show students the two possible structures of pent-2-ene and	Check students' performances and give feedback Check students' performances

Competencies	***Contents***	***Suggested Activities***	***Assessment***
C_5H_{10} • Define geometric (cis-trans) isomerism • Give examples of molecules that show geometric isomerism • Construct models that show cis-trans isomerism		point out that it is not possible to rotate about a carbon-carbon double bond. Students could show that there are branched chain isomers with the formula C_5H_{10}  cis  trans Introduce the term geometric isomerism to describe this type of isomerism. Explain that we use the terms: • cis to describe when different groups are attached to the same side of a plane through the carbon-carbon double bond • trans to describe when different groups are attached to opposite sides of a plane through the carbon-carbon double bond Students should identify that the structures given above are cis-pent-2-ene and trans-pent-2-ene. Students should consider some other examples of alkenes that give cis and trans isomers. Students should be given a project work to construct model that show cis and trans isomerism from locally available materials Students should describe that alkenes are obtained on an	and give feedback Check students' performances and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Explain the general method for preparation of alkenes in a laboratory • Produce ethylene in a laboratory by dehydration of ethanol • Describe the general method for preparation of alkynes in a laboratory. • Prepare acetylene in a laboratory by the reaction of CaC_2 with water.	• Preparation	industrial scale by the cracking of fractions obtained from the distillation of crude oil. In the laboratory alkenes can be made by a number of different routes including: • The dehydration of alcohols with alumina or concentrated sulphuric acid. $R\text{-}CH_2\text{-}CH_2\text{-}OH \rightarrow R\text{-}CH{=}CH_2 + H_2O$ • The dehydrohalogenation of haloalkanes by refluxing them with a base. $R\text{-}CH_2\text{-}CH_2\text{-}X \rightarrow R\text{-}CH{=}CH_2 + HX$ Students should prepare ethene by the dehydration of ethanol. In the laboratory alkynes can be made by a number of different routes including: • The dehydrohalogenation of 1,2-dihaloalkanes by refluxing them with a base. $R\text{-}CHX\text{-}CH_2\text{-}X \rightarrow R\text{-}C{\equiv}CH + 2HX$ • The alkylation of sodium dicarbide with a primary haloalkane $HC{\equiv}CNa + RX \rightarrow HC{\equiv}C\text{-}R + NaX$ • Ethyne can be made by the reaction of calcium carbide and water. $CaC_2 + 2H_2O \rightarrow HC{\equiv}CH + Ca(OH)_2$ Students should be given a chance to prepare ethyne by	Listen students' responses and give feedback Observe students' performances and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Test for unsaturation of ethylene and ethyne • Explain chemical properties of alkenes • Explain chemical properties of alkynes.	• Chemical properties	hydrolysis of calcium carbide. Students should carry out the addition reaction of ethene and ethynewith bromine in tetra chloromethane that is used as a test for unsaturation. • $R\text{-}CH{=}CH_2 + Br_2 \rightarrow R\text{-}CHBr\text{-}CH_2Br$ • $R\text{-}C{\equiv}CH + 2Br_2 \rightarrow R\text{-}CBr_2\text{-}CHBr_2$ The tetra chloromethane loses its colour as the bromine adds across the carbon-carbon double or triple bond. Students should describe that alkenes are generally considered reactive chemicals and this is due to addition across the carbon-carbon double bond. • Addition of halogens to form 1,2 dihaloalkanes $R\text{-}CH{=}CH_2 + X_2 \rightarrow R\text{-}CHX\text{-}CH_2X$ • Addition of hydrogen halides to form haloalkanes $R\text{-}CH{=}CH_2 + HX \rightarrow R\text{-}CH_2\text{-}CH_2X$ • Addition of water to form an alcohol. $R\text{-}CH{=}CH_2 + H_2O \rightarrow R\text{-}CH_2\text{-}CH_2OH$ • Oxidation with cold alkaline potassium manganate (VII) solution to form a 1,2 diol. $R\text{-}CH{=}CH_2 \rightarrow R\text{-}CHOH\text{-}CH_2OH$ Students should discuss that the chemical properties of alkynes are similar to those of alkenes and are determined largely by addition reactions about the triple bond. Students should know that the addition reactions of alkynes	Check the students' performance and give feedback Listen students responses and give feedback Monitor the discussion, check the students' performance and

Competencies	*Contents*	*Suggested Activities*	*Assessment*
• Explain the uses of ethylene and acetylene. • Compare and contrast the properties of ethane, ethene and ethyne	• Uses of ethylene and acetylene.	proceed in two steps. Students should give particular attention to the combustion of ethyne (acetylene) as this has important industrial applications. $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$ + a large amount of heat Oxy-acetylene burners reach temperatures high enough to melt steel. They are widely used in metal 'cutting'. Students should identify in the importance of ethylene and acetylene /ethyne Students should be encouraged to deduce that comparing the chemistry of ethane with that of ethene and ethyne. They are: • Similar in that they undergo combustion to form carbon dioxide and water • Different because ethene and ethyne are unsaturated and take part in addition reactions whereas ethane does not	give feedback Check the students' performance and give feedback
• List the major natural sources of hydrocarbons • Describe natural gas	**6.4 Natural sources of Hydrocarbons** *(2 periods)* • Natural gas	Students should be asked to list the major natural sources of hydrocarbons- natural gas, crude oil and coal. Students should explain that natural gas is composed mainly of methane with smaller amounts of ethane and traces of carbon dioxide and nitrogen. The composition of natural gas	Listen students responses and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***

• Define crude oil
• Explain fractional distillation of crude oil
• Mention products of fractional distillation of crude oil
• Discuss the uses of petroleum products
 	
• Identify the composition of coal
 	
• Describe destructive distillation of coal
	• Crude oil
	
	• Coal
		varies depending on the source but is always over 90% methane.
		
		Students should differentiate that the use of the following terms:
		
		• Crude oil describes the raw material obtained from the ground
		  • Petroleum describes the products after the refining of crude oil
		  • Students should understand how fractions of crude oil are obtained by fractional distillation.
		Students should explain that crude oil is a complex mixture of alkanes which is of little use in the form in which it leaves the ground. The first stage in refining involves fractional distillation which separates the crude oil into a series of fractions which boil over different temperature ranges.
		
		Students should give name of the main fractions and describe their uses. These could include:
		
		• Refinery gases – used for heating in the refinery and bottled gases
		• Petroleum ether – solvents
		• Gasoline – petrol fuel for internal combustion engine
		• Kerosene – jet engine fuel
		• Diesel oil – fuel for diesel engines
		• Lubricating oil – lubricants
		• Paraffin wax – candles and polishes
		• Residue – bitumen for roof sealing and road surfaces
		From this discussion, students could identify that as the
			Check the students' performance and give feedback
			
			Check the students' performance and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
		temperature increases the fractions become: • more coloured • more viscous • less inflammable Students should explain that coal is essentially an impure form of carbon. In addition to carbon, it contains hydrocarbons which are given off as volatiles when the coal is heated in the absence of air. What remains after heating is a purer form of carbon called coke which is used in the blast furnace for the manufacture of iron.	Listen students' responses and give feedback

Chemistry Syllabus

for

Grade 11

General Objectives of Grade 11

To develop understanding and acquire Knowledge of:

- Atomic Spectra and the Quantum Mechanical Model of the Atom;
- The relationship between electronic arrangement of the atoms and periodic trends of the elements;
- Formation of chemical bonding and properties of compounds formed by different types of bonds;
- Predicting the shapes of molecules and intermolecular forces in covalent compounds;
- Kinetic theory of matter and change of physical states;
- Chemical equilibrium in a reversible system and methods of shifting it to the desired direction;
- Sources, properties, compositions, structures, names and uses of organic substances such as alcohols, organic acids, esters, fats and oils.

To develop skills and abilities of:

- using quantum mechanical model of atom to show the structure of atom;
- applying bonding theories to predict properties of substances;
- conducting experiments to observe and analyze the physical properties of substance and determine the type of bonding;
- solving problems related to chemical equilibrium;
- demonstrating experiments to investigate the behaviour of different equilibrium systems and to explain effects of some factors on equilibrium system;
- carrying out laboratory activities involving alcohols, carboxylic acids, esters, fats and oils;
- preparing soap and testing its cleaning action in different types of water;
- design and conduct simple experiments appropriate to their level.

To Develop Habits and Attitudes of:

- Visualizing abstract idea through physical model;
- Appreciating the importance of chemical equilibrium in industrial production;
- Appreciating the interrelationship between electronic structure of the atoms and periodic classification of the elements;
- Developing personality characteristics such as neatness, exactness, diligence, responsibility and carefulness;
- Relating a scientific knowledge to everyday applications.

Unit 1: Atomic structure and periodic properties of the elements *(26 Periods)*

Unit outcomes: students will be able to:

- Discuss the historical development of atomic structure;
- Explain the experimental observations & inferences made by some famous scientists to characterize the atom;
- List and describe the subatomic particles;
- Differentiate the terms atomic mass & isotope;
- Explain electromagnetic radiation, atomic spectra & Bohr models of the atom;
- Do calculations involving atomic structure;
- Describe the quantum mechanical model of the atom & the related postulates and principles;
- Demonstrate an understanding of periodic law & how electronic configurations of atoms are related to the orbital diagrams & can explain periodic trends;
- Describe scientific enquiry skills along this unit: inferring, predicting, classifying, comparing & contrasting, communicating, asking questions and making generalization.

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Students will be able to: • Identify major changes in Atomic Theory • Evaluate postulates of Dalton's Atomic Theory with the present situation • Describe Modern Atomic Theory and compare them with the Dalton's Atomic Theory • Discuss the laws of chemical combination and relate them with Dalton;s Atomic Theory	***1. Atomic Structure and Periodic Table*** **1.1 Historical development of the atomic nature of substances (brief review) (1 period)** **1.2 Dalton's Atomic Theory and the Modern Atomic Theory** *(1 periods)* • Postulates of Dalton's Atomic Theory • Postulates of Modern Atomic Theory • How the theory explains the mass laws	Students should discuss: • early Greek concepts of the composition of matter based on visionary beliefs but not on evidence (Democritus Vs Zeno of Elea) • why Dalton's Atomic theory is considered scientific even though it had errors • how scientific ideas develop based on previous scientific findings Students should identify that • the Postulates of Dalton's Atomic theory as they were formulated by Dalton himself then • the modified version of it (the Modern Atomic Theory) as it stands today Let students discuss on the mass laws (law of conservation of mass, law of definite composition, and law of multiple proportions) so that they can see the connection between each one of them. The teacher may act as the Devil's advocate by telling the students that you don't believe in the law of conservation of mass by raising issues the students are most likely to raise as ' evidences' against the law. The mass of a piece of wood	Monitor the discussion and give summary Check on through questions and give feedback Guide the students to comprehend how Dalton's postulates explain the mass laws one by one

Competencies	*Contents*	*Suggested Activities*	*Assessment*
		before and after it is burnt, in an ordinary stove, to ashes is not the same- showing that mass can be created. A seedling growing shows increase in mass which can be taken as 'evidence' that mass can increase during a biochemical reaction. Then work backwards to show them that indeed mass is conserved by showing them if one burned the wooden log inside a completely closed chamber, that does not allow any gases or otherwise to leave the chamber, then there would not be mass loss. Look for more similar examples that the students take as 'evidences' against the law and guide them so that they correct the misconceptions they earlier formulated, on their own.	
• Discuss the discovery of electron • Describe the properties of cathode rays • Define the terms: radioactivity, radioactive decay and radio-isotope. • Describe the common types of radioactive emissions. • Discuss the alpha scattering experiment. • Describe the major contribution of experiments by Thomson, Millikan and Rutherford concerning atomic structure.	**1.3 Early experiments to characterize the atom** *(3 periods)* • Discovery of *the* electron • Radioactivity and discovery of nucleus • Discovery of neutron	Students should discuss in group on the early experiments carried out and what lessons learned from their findings (the discoveries of fundamental subatomic particles and the atomic nucleus) helped in understanding the composition and structure of the atom • J.J. Thompson-electron • Ernest Rutherford-nucleus & proton • Chadwick-neutron Students should explain that though Rutherford concluded that an atom must possess a very tiny nucleus that contains all of the positive charge in the atom and nearly all its mass, this is the only way he could account for the scattering of some α-particles at large angles from thin metal foils, and the fact that most of the α-	Monitor the discussion, check the students' performance and give feedback Listen students responses and give feedback

Competencies	*Contents*	*Suggested Activities*	*Assessment*
		particles passed through the foil nearly unaffected. Students should identify that the mass of the nucleus could not be accounted for with only protons and this became evident when Chadwick, another student of Rutherford, discovered a nuclear particle, without electrical charge-hence named neutron. Let the teacher summarize on the continuity of ideas (and the importance of being in the right place at the right time) considering the pivotal role Rutherford and his students played in discovering the constituents of the nucleus • how the discovery of radioactivity by Becquerel was necessary for the discovery of the nucleus of the atom • how the discovery of the neutron helped to discover the presence of isotopes	Check the students' performance and give summary
• Describe make-up of the nucleus	**1.4 Make up of the nucleus** *(2 periods)* • Constituents of the nucleus	Students should differentiate atomic number, mass number and atomic mass. Students should identify that atomic number was discovered (not protons) by a young British physicist, Mosley in 1913 by correlating x-ray spectrum of each metal with its order in the periodic table (its atomic number) and realized that the nuclear charge increased by one unit for each element. In other words atomic number is an element's position number in the periodic table and is numerically equal to the number of protons in the nucleus of an atom.	Check on a sample exercises and give feedback
• Define atomic mass. • Define isotope.	• Atomic mass and isotopes	Students should explain that the total number of nucleons (protons and neutrons) found in the nucleus is called mass	Listen students responses and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Calculate the relative atomic mass (atomic mass) of naturally occurring isotopic elements.		number. Numerically mass number and atomic mass are very close but they should not be taken to be one and the same. Atomic mass is the average of the naturally occurring isotopes of an element weighted according to their abundances. Students need to be given group assignments to calculate the atomic mass of few elements like chlorine, bromine, carbon and hydrogen from the masses and abundances of the corresponding isotopes. Students should find the number of naturally occurring isotopes. Students should explain that isotopes are different atoms (not identical) of the same element. Analogies would be helpful here to make the concept clear. The word isotope comes from the Mendeleve's periodic law (atomic properties of elements are periodic functions of their atomic masses.) Students should identify that isotopes of an element are different atoms not identical. Students should be able to see that our models (mental perceptions) of the atom become more accurate with new findings emerging that help scientists formulate new models that agree with facts waiting to be explained.	Check the students' performance and give feedback Listen students responses and give feedback
• Characterize	**1.5 Electromagnetic Radiation (EMR) and**	Students should be able to see that the nature of the nucleus has been known for quite some time since the days of Rutherford and his associates. What has been elusive is the position and	

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Electromagnetic Radiation (EMR) in terms of wave length, frequency and speed. • Calculate the wavelength and frequency of the EMR. • Explain that light has both wave and particle nature. • Explain that the emission spectra of atoms consist of series of lines • Define photon as a unit of light energy. • Explain how photon theory explains the photoelectric effect and the relation between photon absorbed and electron released. • State Bohr's assumption of energy of electron in hydrogen atom.	**Atomic Spectra** *(8 periods)* • Electromagnetic Radiation • Atomic Spectra • The quantum theory and photon • The Bohr Model of the Hydrogen atom	velocity of electrons. Students should describe electromagnetic radiations and express the energies of waves (photons) in terms of λ & ν. Students should explain that light has both wave and particle nature. Students should explain that atomic or line spectra are produced from emission but not absorption of distinct frequencies of photons. Let students identify a line spectrum consists of only relatively few wavelengths that is produced from light emitted by excited atoms. It is a unique feature of an element that can be used for identification purposes. Let students to discuss in group on the concept of waves treated as particles and vice versa. Students should give the meaning of the word quantum which is a packet of energy equal to hv. It is the smallest quantity of energy that can be emitted or absorbed. Energy related to emissions or absorptions are whole number multiples of this	Check the students' performance and give feedback Check the students' performance and give feedback Monitor the discussion and give summary

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Calculate the radius of electron orbit, the electron velocity and the energy of an electron using Bohr model.	• Limitations of the Bohr Theory	quantum, E = nhv. Students should identify that the Rutherford model of an atom could not explain why the emission spectrum of an atom was not a continuous one instead of being discrete. Students should discuss what the Bohr model of the atom looks like including what make it a better model than the previous ones and its limitations in explaining certain facts. Let students draw pictures of elements individually whose atomic number is less than 30 and then discuss them in groups. The Bohr model of an atom was successful in accounting for the spectral lines of H-atom, which indicated he was on the right track. His model, however, failed to predict the wavelengths of spectral lines of atoms more complicated than hydrogen demonstrated that there was a basic flaw somewhere in the theory.	Monitor the discussion, check the students' performance and give feedback
• Explain that the line spectrum of hydrogen demonstrates the quantized nature of the energy of its electron. • Explain that atoms emit or absorb energy when they undergo transitions from one state to another • Explain the short comings of Bohr's theory. • State Heinsberg's uncertainty principle • Describe the	**1.6 The Quantum Mechanical Model of the Atom** *(5 periods)* • Quantum numbers. • Shapes of atomic orbitals	Students should explain the relationship between atomic (line) spectra and Bohr model of the hydrogen atom. Students should identify the breakdown of classical mechanics in relation to subatomic particles like the electrons, hence necessity for a new theory-the Quantum mechanical model of the atom. Students should explain that according to the quantum mechanical model of the atom an electron is described in terms	Check on a sample questions and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
significance of electron probability distribution. • Explain the quantum numbers n, l, m_l, m_s • Write all possible sets of quantum numbers of electrons in an atom. • Describe the shapes of orbital designated by s, p and d		of 4 quantum numbers, of which three describe the orbital- the space the electron is supposed to occupy and the 4^{th} relates to the spin of the electron. Students should describe the set of the quantum numbers as a street address of a person in a country. The four quantum numbers are principal quantum number, subsidiary quantum number, magnetic quantum number, and spin quantum numbers. Students should explain that there are different shapes of atomic orbital. For example, S-spherical, P-dumbbell. They also differ in size depending upon their energy. Students explain the way scientific ideas progress. Let the students to form groups and discuss to see how our beliefs about structure of matter evolved. What was once believed to be continuous is now without doubt particulate (atom). Dalton's atom was considered indivisible; now we know there are fundamental particles inside the atom. It is now clear what is found in the nucleus but there is still some ambiguity about the exact location and energy of the electrons that are known to move around the nucleus. The era of modern atomic theory begins with Dalton's model of the atom. This should not make the students think that his model is the best of all similar models. Ask students to list down what has been retained in the modern atomic theory from Dalton's postulates. Help students organize a debate to award a prize to one prominent scientist from among	Check students' performances and give feedback Listen students responses and give feedback Guide students, monitor the discussion and give summary

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Explain Aufbau principle. • Explain pauli-exclusion principle. • Explain Hund's rule	**1.7 Electronic configurations and orbital diagrams** *(2 periods)* • Aufbau principle • Pauli-exclusion principle • Hund's rule	the many who contributed to the current model of the structure of the atom. This will give them a chance to revise the unit. Students should differentiate the following principles to be used in writing electron configurations of atoms along with the quantum numbers	Observe students' activities and give feedback
• Write ground state electron configurations of multi-electron atoms.	• Ground state electronic configuration of the elements.	• Aufbau's principle • Pauli's Exclusion principle • Hund's principle Ground state electronic configurations of the elements can be solved if students are given the atomic number in conjunction with the charge of the atom using aufbau principle as there is only one of its kinds. However, to check that they know the difference between excited and ground states ask students individually to write excited electronic configurations for some elements or ions.	Check on a sample exercises and give feedback
• Correlate the electron configuration of elements with the periodicity of elements. • Give a reasonable explanation for shape of the periodic table. • Classify elements as representative, transition and inner-transition elements.	**1.8 Electronic Configurations and The Periodic table of The Elements** *(4 periods)* • The modern periodic table • Classification of the elements	Students should differentiate the Mendeleve's and Modern periodic laws.	Listen students' responses and give feedback Check on a

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Explain the general trends in atomic radius, ionization energy, electron affinity, electro negativity and metallic character of elements within a period and a group of the periodic table. • Write the advantages of periodic classification of elements.	• Periodic properties • Advantages of periodic classification of elements.	Students should use the electronic configurations of elements to locate the position in the periodic table and vice versa and their properties. Give assignments individually and then ask them to find out the differences, if there are any. Students should explain that elements can be classified in the periodic table according to their electronic configurations. Students should discuss the general trends in periodic properties of elements across the period and along the group in the periodic table. Students should use the periodic table for further study of elements and their compounds. Let students discuss in groups on the advantages of periodic classification of elements.	sample exercises, observe students' performance and give feedback Monitor the discussion and give feedback Check students' performance and give feedback Monitor the discussion and give summary

Unit 2: Chemical Bonding *(30 Periods)*

Unit outcomes: Students will be able to:

- Explain that a chemical bond is an attractive force between particles;
- Demonstrate an understanding of the formation & general properties of substances containing ionic, covalent & metallic bond;
- Draw Lewis structure for simple ionic & covalent compounds;
- Identify the origin of polarity within molecules;
- Describe the formation & nature of hydrogen bonds, dipole-dipole forces and London forces;
- Explain the bonding models (Lewis model, valence bond model & molecular orbital model) & show the usefulness of the bonding theories in explaining & predicting molecular properties (bond angle, bond length, bond energy, etc…);
- Explain how the properties of a substance (solid or liquid) depends on the nature of the particles present and the type of intermolecular forces;
- Discuss the importance of intermolecular forces in plant & animal life:
- Explain how the Valence Shell Electron Pair Repulsion(VSEPR) model can be used to predict molecular shape;
- Discuss the types of crystalline solid (ionic, molecular, covalent network, or metallic) formed by a substance & describe their properties;
- Conduct experiments to observe & analyze the physical properties of different substance to determine the type of bonding present;
- Describe scientific enquiry skills along this unit: observing, inferring, predicting, classifying, comparing & contrasting, making models, communicating, asking questions, applying concepts, relating cause & effect and making generalization.

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Students will be able to: • Define chemical bonding • Reason out why atoms form chemical bonds	**2. Chemical Bonding and Structure** **2.1. Introduction** *(1 period)*	Students should define chemical bonding in the simplest way such as: i. that holds the parts of a chemical structure together or ii. a force which holds chemical species together. You might sometimes refer to bonding as a 'chemical bond', and at other occasions refer to it as 'an interaction' or 'the force' holding molecules together. Yet different students may well have their own idiosyncratic ways of using these various terms that teachers are not aware of. All these terms which mean the same thing could be used interchangeably but students may not see it that way. Besides students should describe how bonding has resulted in the formation of • an ever increasing number of substances from a limited number of elements • substances with different properties from the elements they are formed • substances accompanied with energy change(energy consuming or releasing)	Check students' performances and give feedback
• Describe chemical bonding using octet rule	• Octet rule	Students should explain that the octet rule is an observation that correlates atomic stability with outer shell carrying eight electrons.	Check students' performances and give feedback
• Describe the types of		Students should discuss the types of chemical bonding and	

Competencies	***Contents***	***Suggested Activities***	***Assessment***
chemical bonding and their mechanisms of the bonding processes	• Types of chemical bonding	how they relate to the electronic structures of the atoms that are bonded together. Students should also describe the importance of bonding, especially in biological systems.	Monitor the discussion, check students' performances and give feedback
• Define ionic bonding.	**2.2 Ionic Bonding** *(5 periods)*	Students should explain that an ionic compound is stable because of the very large lattice energy that is released when the oppositely charged ions come together to produce the ionic solid. If it were not for this lattice energy, ionic compounds would not exist. Thus in the gas phase the ions, Li^+ (g) and F^-(g), are less stable (i.e., of higher energy) than Li(g) and F(g) and therefore Li(g) and F(g) would not react spontaneously to produce the ions. This is a good indication how easily students revert to simple and familiar ideas. Students need to attempt chemical stability assignments individually and discuss them in groups. Eg. Na^+/Na/Na^{7-}; Cl^{7+}/Cl/Cl^- and C^{4+}/C/C^4.	Listen students explanation,monitor the discussion, check students' performances and give feedback
• Use Lewis electron dot symbols to depict main group elements. • Describe ionic bonding using Lewis electron dot symbols. • List the favorable conditions for the formation of ionic bond. • Explain the formation of ionic bonding • Define lattice energy • Calculate lattice energy of ionic crystal from a	• Lewis electron dot symbols • Formation of ionic bonding	When discussing this section focus should be on: • Showing the structures of elements using the Lewis dot formulas as entry to showing what constitutes ionic bonds. • Formation and set of criteria for the formation of ionic bonding • how transfer of electrons between the atoms forming an ionic bond results in the formation of stable ions, isoelectronic to nearby noble gas elements	Check students' performance on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
given data using the Born-Haber cycle • Give examples of ionic compounds • Discuss the exceptions to octet rule	- The Born-Haber cycle - Factors affecting formation of ionic bonding • Exceptions to octet rule	• Students should discuss and give their reflection on factors that influence the formation of ionic compounds (one needs to be of low ionization energy and electron affinity and the second with high ionization energy and electron affinity and when the lattice energy of the resultant compound is high) Students should identify the problem of over generalizing the Octet Rule; it works beautifully for period 2 elements but has limitations elsewhere	Monitor the discussion, check students' performances and give feedback
• Describe the properties ionic compounds	• Properties of ionic compounds	Students should describe the concept that properties of ionic compounds reflect the kinds of particles that are within them. Students should explain the strong attractive forces between ions cause ionic compounds to have their characteristic properties (it is important to highlight that ionic compounds conduct electricity when melted but not in the solid state)	Check students' performance and give feedback
• Carryout an activity to investigate the melting point and solubility of some ionic compounds (NaCl and $CuCl_2$)		Students should be given samples of ionic compounds (PbI_2, NaCl, $CuCl_2$) and asked to investigate their conductivity, solubility, and melting points.	Observe students activities and give feedback
• Define covalent bonding • Explain the formation of covalent bonding • Give examples of covalent molecules	**2.3 Covalent Bonding** *(14 periods)*	Students should explain covalent bond is very different from ionic bond and this in turn gives rise to very different properties from ionic compounds: • sharing a pair of electrons between two atoms lowers	Check students' performances and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
		their energy hence making the association more stable than the starting atoms • covalent bonding is favored when the difference between the ionization energies and electron affinities of the combining atoms is not large • it is important from the outset to stress that substances containing covalent bonds only are called molecules with ample examples	
• Draw Lewis structures or electron dot formulas of some covalent molecules	• Formation of covalent bonding • Representation of covalent bond. - drawing Lewis structures	Students should explain the connection between structure and properties of molecules early on and therefore must grasp the techniques of drawing Lewis structures of simple molecules. • the need to determine skeletal structure • be sure the students learn and use the rules of counting and distributing valence electrons among the bonds and atoms in the skeletal structure	Check students' performance and give feedback
• Illustrate the formation of coordinate covalent bonding using examples	• Coordinate covalent bonding	Students should identify that the electrons to be shared by the two nuclei connected by a covalent bond need not be always contributed by both atoms; one could donate and the second accept. This is how the Coordinate Covalent bond is formed. Difference in the source of the electrons may not result in difference in the covalent bonds formed. (eg the bonds in H_3O^+ are all identical even if it is formed from a reaction between H^+ and H_2O)	Check on a sample exercises and give feedback
• Define resonance structures • Draw resonance structures		Students identify the limitations of the Resonance concept	Check students'

Competencies	***Contents***	***Suggested Activities***	***Assessment***
of some covalent molecules and polyatomic ions • Discuss the exceptions to the octet rule in covalent bonding • Distinguish between polar and non-polar covalent molecules • Describe the properties of covalent molecules • Carryout an activity to investigate the effects of heat, electricity and some solvents on	• Resonance structures • Exceptions to the octet rule in covalent bonding • Polar and non-polar covalent molecules • Properties of covalent compounds	and see it only as a last resort to give a structure of a molecule when there is more than one reasonable way of distributing electron pairs in a molecule Students should identify that there are exceptions to the octet rule by giving them few simple examples. Students should explain that ionic substances are always polar (the extreme case of polarity is ionic bond) but that molecules could be either very polar, weakly polar or non-polar at all which dependence on the composition and shape of the molecule. It is important that ample examples should be given here to determine the net dipole moments which ultimately decide polarity. Using the electro negativity table, let students predict bond stability (large electro negativity) and dipole formation of molecule. Students should discuss the general properties of covalent compounds. Students should explain the concept that properties of covalent compounds reflect the kinds of particles that are within them. Students should describe how the properties of molecules depend on the net dipole moment in particular. Students should be given samples of covalent compounds (naphthalene, graphite, iodine and ethanol) and asked to investigate their conductivity and solubility.	performance and give feedback Check students' performance on a sample exercises and give feedback Observe students' activities and give

Competencies	***Contents***	***Suggested Activities***	***Assessment***
covalent compounds (naphthalene, graphite, iodine and ethanol) • Describe the valence shell electron pair repulsion theory (VSEPR) • Distinguish the bonding pairs and non-bonding pairs of electrons • Describe how electron pair arrangements of molecules can be predicted from the number of electron pairs • Explain why double bonds and lone pairs cause deviation from ideal bond angles • Explain the term dipole moment with the help of a diagram • Describe the relationship between dipole moment and molecular geometry • Describe how bond polarities and molecular shapes combine to give	**2.3.1 Molecular Geometry** • Valence shell electron pair repulsion (VSEPR) Theory • Electron pair arrangement and molecular shape • Guidelines for applying VSEPR model. • Molecular shape and molecular polarity - Bond polarity - Bond angle	Students should discuss the VSEPR theory and its connection to Lewis diagrams of molecules in describing molecular shapes. Students should describe the concept of lonepair-lonepair repulsion> lonepair-bondpair repulsion > bondpair-bondpair repulsion using a balloon model of water. Give assignments to the students individually to construct the five shapes of molecules and discuss them in groups. Students should use guidelines for applying VSEPR theory to draw the shapes of molecules. Ball and stick models are helpful to students as they attempt to visualize the geometry of molecules (use locally available materials). Students should determine shapes and polarity of molecules by combining the Lewis and VSEPR theories. When considering bond polarity dipole moments should be treated qualitatively in conjunction to geometry of the bonds. Students should identify how some properties of similar compounds differ because of varying molecular shapes and structures.	feedback Monitor the discussion and give feedback Check students' performance and give feedback Check students' performance and give feedback Give assignment and check students' performances

Competencies	***Contents***	***Suggested Activities***	***Assessment***
molecular polarity • Predict the geometrical shapes of some simple molecules on the basis of hybridization and the nature of electron pairs • Discuss how the valence shell electron pair repulsion theory is used to explain the molecular parameters like bond angle and polarity of the molecule • Construct models to represent shapes of some simple molecules	- Dipole moment • Predicting the shapes of Molecules	Students should be asked to construct models (from locally available materials) to represent shapes of simple molecules. Students should demonstrate the ability to predict avoids the necessity of memorizing hundreds of individual molecular shapes. It is very important to help students see that the particles in molecular substances are molecules whereas in ionic substances the particles are positive and negative ions. The fact that molecular substances are either gases, liquids or soft solids whereas ionic substances are usually hard solids with high melting point does not imply that covalent bonds are in general weaker than ionic bonds; the forces that should be considered in molecular substances is the various types of intermolecular associations or bonds with varying strength. Students often do not count intermolecular forces as bonds and these needs to be corrected.	Check students' performance on a sample exercises and give feedback Observe students' performances' and give feedback
• Define intermolecular forces • Name the different types of intermolecular forces • Explain dipole-dipole interactions • Give examples of dipole-dipole interaction • Define hydrogen bonding • Explain the effects of	**2.3.2. Inter molecular forces in covalent compounds** • Dipole- dipole force -hydrogen bonding • Dispersion or London force	Students should define that an intermolecular force is a force of attraction between molecules. Students differentiate that Dipole-Dipole force and hydrogen bonding occur in some molecules, but Dispersion or London forces are common to all molecules. Students should use polarity to explain hydrogen bonding and should describe the properties of substances having	Check students' performance and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
hydrogen bond on the properties of substances		hydrogen bonding.	
		Students should identify that the hydrogen bonding that causes ice to occupy more volume and therefore less dense is important both to ice skaters and to aquatic plants and animal. If ice were denser, the ponds and streams would freeze from the bottom up. The plants and animals would die.	Observe students' performance and give summary
• Give reason why H-bonding is stronger than ordinary dipole-dipole interaction • Explain dispersion (London) forces • Give examples of dispersion forces • Predict the strength of inter molecular forces for a given pair of molecules		Let students compare the strength of H-bonding and ordinary dipole-dipole interaction Students should explain dispersion forces and give some examples Let students compare the strength of intermolecular forces in a given pair of molecules	Give assignment and Check students' performances Check on a sample exercises and give feedback
• Explains how metallic bond is formed	**2.4. Metallic Bonding** *(1 periods)* • Formation of metallic bond • Electron Sea Model	Students should explain metallic bonding is not the sharing or loss or gain of electrons. It is just a loose association of metal ions and electrons they have lost. Students should discuss that the electron Sea model depicts metallic bonding as a situation where all the metal atoms in a sample pool their valence electrons into an evenly distributed 'sea' of electrons that 'flows' between and around the metal-ion cores and attracts them together.	Listen students' responses and give summary Monitor the discussion and check students'

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Explain the properties of metals related to the concept of bonding • Carryout an activity to investigate the conductivity, malleability and ductility of some metals and nonmetals (Al, Cu, Fe, Sn, Zn, S, C- charcoal, C- graphite and Si)	• Properties of metals related to the concept of bonding.	Unlike the localized electrons in covalent bonding, electrons in metallic bonding are delocalized, moving freely throughout the piece of metal. Students should explain that the physical properties of Metals vary over a wide range. Almost all are solids with moderate to very high melting and extremely high boiling points. Periodic trends are consistent with the model. Ca has higher melting point than K- a reflection of 2 vs 1 valence electrons. They are malleable and ductile-the metal ions slide past each other when force is applied. They are good conductors of electricity and heat- because of the mobility of the delocalized electrons. Students could be given samples of metals and non-metals (Aluminum, copper, iron, tin, zinc, charcoal, graphite and silicon) and asked to investigate their conductivity, malleability and ductility.	performance Give summary Observe students' activities and give summary
• Name the two bonding theories • Explain the valence bond theory. • Distinguish between the Lewis model and the valence bond model. • Discuss the overlapping of orbital in covalent	**2.5.Chemical Bonding Theories** *(8 periods)* **2.5.1.Valence Bond Theory (VBT)** - Overlap of atomic	Let students describe MOT and VBT are complementary and therefore should be used when one has more advantage than the other. Students should identify that VBT is a theory that explains covalent bond formation by hybridization and overlapping of atomic orbitals.	Check students' performances and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
bond formation • Explain hybridization • Show the process of hybridization involved in some covalent molecules • Draw hybridization diagram for the formation of sp, sp^2, sp^3, sp^3d and sp^3d^2 hybrids. • Suggest the kind of hybrid orbitals on the basis of the electron structure of the central atom. • Predict the geometrical shapes of some simple molecules on the bases of hybridization and the nature of electron pairs. • Discuss the hybridization involved in compounds containing multiple bonds. • Explain bond strength and bond length. • explain molecular orbital theory • describe molecular orbital-using atomic orbitals • describe bonding and	orbitals (sigma and Pi bonds) - Hybridization of orbitals **2.5.2 Molecular Orbital**	Students could draw hybridization diagram and predict the geometrical shapes of some simple molecules. Students should give the kind of hybrid orbitals by considering the electron structure of the central atom Let students discuss in group and present to the class Let the students identify the hybridization of atoms involved in double and triple bonds. Students should compare the strength and bond length of single, double, and triple bonds Students should explain the basic assumption of MOT Students should show how molecular orbitals could form	Check students' performance on a sample exercises and give feedback Check on a sample exercises and give feedback Monitor the discussion and give summary Check students' performance on a sample exercises and give feedback Check students'

Competencies	***Contents***	***Suggested Activities***	***Assessment***
anti-bonding molecular orbitals • draw molecular orbital energy level diagrams for homonuclear diatomic molecules • write the electron configuration of simple molecules using the molecular orbital model • define bond order and determine the bond order of some simple molecules and molecule-ions • determine the stability of a molecule or an ion using its bond order; and predict magnetic properties of molecules	**Theory (MOT)**	from atomic orbitals Students should discuss the difference between bonding and antibonding MOs Students should draw molecular orbital energy diagram for some homonuclear diatomic molecules Students should write the electron configuration of simple molecules using molecular orbital model Students should calculate the bond order of some simple molecules and ions Students should evaluate the magnetic properties of some simple molecules compare the strength and bond length of single, double, and triple bonds Students should evaluate which theory (VBT or MOT) perfectly explains all aspects of bonding	performance and give feedback Check on a sample exercises and give feedback
• Define crystal • Name the four types of crystalline solids and give examples. • Mention the type of attractive forces that exist within each type of crystalline solids • Describe the properties of each type of crystalline solids • Build a model of sodium	**2.6.Types of crystals** *(1 period)* • Ionic crystal • Molecular crystal • Covalent network crystal • Metallic crystal	Students should explain that types of crystals are distinguished from each other by the type of intermolecular forces between the individual molecular particles or ions which in turn determine physical properties like melting and boiling points and solubility in different solvents.	Listen students'

Competencies	***Contents***	***Suggested Activities***	***Assessment***
chloride crystal structure		Students should describe the properties of each type of crystalline solids Students should be asked to construct a model of NaCl structure from ball and sticks or other locally available materials.	responses and give summary Check students' performance and give feedback

Unit 3: Physical states of matter *(18 periods)*

Unit outcomes: Students will be able to:

- Discuss the kinetic molecular theory and properties of the three physical states of matter.
- Explain the behaviour of gases by using the variables volume, temperature, pressure and number of moles.
- Distinguish terms like ideal gas, diffusion, evaporation, boiling, condensation, vapour pressure, boiling point, molar heat of vaporization, molar heat of condensation, melting, fusion, sublimation, melting point, freezing point, molar heat of fusion, and molar heat of solidification.
- Analyse the gas laws.
- Develop skills in solving problems to which the gas laws apply.
- Perform activities to illustrate gas laws.
- Carryout experiments to determine the boiling points of liquids and the melting point of solids.
- Demonstrate an experiment to show phase changes.

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Students will be able to:	***3.1.The physical states of matter***		
• Name the three physical states of matter. • Give examples for each of the three physical states of matter • Compare and contrast the main types of inter molecular forces.	**3.2. Introduction** *(1 period)*	Students should discuss the three physical states of matter: solids, liquids and gases. Students should identify that, although it is seldom found in everyday life, there is the fourth state known as the plasma state. Students should give everyday examples of substances that occurring each of these states. Let students compare and contrast the main types of inter molecular forces	Monitor the discussion and give summary Check students' performance and give feedback
• State kinetic theory of matter • Explain the properties of the three physical states of matter in terms of kinetic theory	**3.3. Kinetic theory and properties of matter** *(2 periods)* • Kinetic theory of matter • Properties of matter	Students should explain the kinetic theory of matter: • All matter is composed of particles which are in constant motion • The particles possess kinetic energy (movement energy) and potential energy • The difference between the three states of matter are due to their energy contents and the motion of the particles Students should identify that in a solid:	Check students' performance and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Compare and contrast the three physical states of matter		• Particles are in fixed positions • Particles are able to vibrate but not translate Students should discuss how the kinetic theory explains the properties of solids e.g. fixed shape, can't be compressed Students should identify that in a liquid: • The particles have more energy than in a solid • The particles are not in fixed positions but able to move • The particles are in continual constant motion • The particles are closely packed but less so than in a solid Students should discuss how the kinetic theory explains the properties of liquids e.g. taking the shape of a container, can only be compressed a small amount. Students should describe that in a gas: • The particles have more energy than in a liquid • There are large distances between particles compared to liquids and solids • Particles move about in all directions at high speed Students should discuss how the kinetic theory explains the properties of gases e.g. diffusion to fill the space available, easy to	Monitor the discussion and give summary Check students' responses and give feedback Monitor the discussion and give summary

Competencies	***Contents***	***Suggested Activities***	***Assessment***
		compress.	
	3.4. The gaseous state	Students should discuss the differences between the properties of the three states of matter based on the kinetic theory.	Monitor the discussion and give feedback
• Explain the assumptions of kinetic molecular theory of gases • Describe properties of gases using kinetic molecular theory • Describe the behaviour of gases by using the variables V (volume),T (Temperature), P (pressure) and n (number of moles)	***(10 periods)*** • ***The kinetic molecular theory gases*** • The gas laws	Students should be requested describe the kinetic molecular theory assumptions and use them in explaining properties of gases Students should identify that the behaviour of gases is explained by a series of gas laws which study the relationships among variables: • V denotes volume • T denotes temperature • P denotes pressure • n denotes number of moles Students should differentiate some common units we use for the above mentioned variables	Check students' performance and give feedback
• State Boyle's law	- Boyle's law	Students should explain Boyle's law: Students should show how the volume of a given mass of gas is inversely proportional to its pressure provided that the temperature remains constant' Students should show that this can be expressed mathematically	Listen students' responses and give

Competencies	***Contents***	***Suggested Activities***	***Assessment***
		as: • $P \propto \frac{1}{V}$ or PV = K where K is a constant When we change the pressure or volume at constant temperature it follows that: • $P_1V_1 = P_2V_2$ where subscripts denote initial and final conditions Students should be asked to conduct a practical activity to prove the validity of Boyle's law as follows: • Two tubes partially filled with mercury joined by rubber tubing giving a U-tube arrangement • One tube is calibrated, contains air and is sealed by a tap • By moving the un-calibrated tube up and down the volume of air in the calibrated tube can be varied The pressure exerted on the air is obtained from the difference in height of the mercury in the two tubes • Students should be requested to plot a graph of P against 1/V and obtain a straight line Students should carry out calculations using Boyle's law. Students should state Charles' law: 'the volume of a fixed mass of gas at constant pressure is directly proportional to its absolute temperature'	summary Check students' performances and give feedback Observe students' activities and give feedback Check on a sample exercises and give feedback Check students' performances and
• Perform an activity to show changes in volume and pressure of gases to illustrate Boyle's law • Apply Boyle's law in solving problems	Charles' law		

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• State Charles' law • Conduct an activity to show changes in volume and temperature of gases to illustrate Charles' law. • Apply Charles' law in solving problems • State Gay Lussac's law:	- Gay Lussac's Law	Students should know that this can be expressed mathematically as: • $V \propto T$ or $\frac{V}{T} = K$ where K is a constant When we change volume or temperature at constant pressure it follows that: • $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ where subscripts denote initial and final conditions Students should conduct a practical activity to demonstrate Charles' law as follows: • Set up a round-bottomed flask fitted with a bung and delivery tube • Invert the flask and place the delivery tube in a beaker of water • Investigate what happens to the volume of air in the flask when it is heated or cooled by observing whether bubbles of air are forced out or water is drawn up the delivery tube Students should carry out calculations using Charles' law. Students should state Gay Lussac's law: 'at constant volume, pressure of a fixed amount of a gas varies directly with the temperature Students should show that this can be expressed mathematically	give feedback Observe students' activities and give feedback Observe students' activities and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Derive combined gas law equation from Boyle's law and Charles' law • Use the combined gas law to calculate changes in volume, pressure or temperature • Define an ideal gas • Derive an ideal gas equation from Boyle's law, Charles' law and Avogadro's law	- Combined gas law - Ideal gas equation	as: • $P \propto T$ or $\frac{P}{T} = K$ where K is a constant Students should show how Boyle's law and Charles' law combine to give one law called the combined gas law. Students should identify that this can be expressed mathematically as: • $\frac{PV}{T} = K$ where K is a constant More generally for changing conditions: • $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ Students should carry out calculations using the combined gas law. Students should explain that an ideal gas is a hypothetic gas that exactly obeys the gas laws. In reality real gases only obey the gas laws closely at high temperatures and low pressures as under these conditions their particles are far apart. Students should describe that the ideal gas law is a combination of Boyle's law, Charles' law and Avogadro's law.	Check on a sample exercises and give feedback Observe students' activities and give feedback Check on a sample exercise and give feedback Listen students' responses and give summary Observe students' activities and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Compare the nature of real gases with ideal gases • Solve problems related to ideal gas equation • Define diffusion • State Graham's law of diffusion	Graham's law of diffusion	• Boyle's law $V \propto 1/P$ (n and T constant) • Charles' law $V \propto T$ (n and P constant) • Avogadro's law $V \propto n$ (P and T constant) It follows from these that: • $V \propto \frac{nT}{P}$ • $V = \frac{RTn}{P}$ or $PV = nRT$ • where R = molar gas constant = 8.314 $\frac{L.Kpa}{mol.k}$ or 0.082 $\frac{L.atm}{mol.k}$ or 8.314 $\frac{J}{mol.k}$ Students should be requested carry out calculations using the ideal gas law. Students should define diffusion of a gas is the spreading out of its particles so that they are evenly distributed through the whole of the space available. Students should describe Graham's law of diffusion: 'At constant temperature and pressure, the rate of diffusion of a gas, r, is inversely proportionally to the square root of its density, ρ, or molar mass, M.' Students should show that this can be expressed mathematically as	Check on a sample exercises and give feedback Check students' performance and give feedback Observe students' activity and give feedback

Competencies	*Contents*	*Suggested Activities*	*Assessment*
• Carry out an activity to compare the rate of diffusion of two different gases • Apply Graham's law of diffusion in solving problems	**3.5. The liquid state**	follows: • $r \propto \frac{1}{\sqrt{\rho}}$ or $r = \frac{K}{\sqrt{\rho}}$ where k is a constant • $r \propto \frac{1}{\sqrt{m}}$ or $r = \frac{K}{\sqrt{m}}$ where k is a constant Also the rate at which a gas diffuse is inversely proportional to the time taken therefore: • $r \propto \frac{1}{t}$ so comparing two gases $\frac{r_1}{r_2} = \frac{t_2}{t_1}$ It also follows that • $\frac{r_1}{r_2} = \sqrt{(\rho_2 / \rho_1)} = \sqrt{(m_2 / m_1)}$ Students should compare the rate of diffusion of gases as follows: • Porous pot fitted with a cork and delivery tube • Delivery tube attached to a U-tube containing coloured water • Porous pot placed in beaker of hydrogen • Pressure in pot increases as hydrogen diffuses in quicker than the air diffuses out • Porous pot placed in beaker of carbon dioxide • Pressure in pot decreases as air diffuses out quicker than carbon dioxide diffuses in • Pressure changes shown by levels of coloured water in the limbs of the U-tube	Guide and check students' performance Give a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Explain the terms: evaporation, boiling condensation, vapour pressure, boiling point, molar heat of vaporization and molar heat of condensation • Carry out an activity to	*(2 periods)* • Boiling • Condensation • Energy changes in boiling and condensation • Evaporation • Vapour pressure • Determination of vapour pressure and boiling	Students should carry out calculations using the different versions of Graham's law Students should describe the simple properties of liquids from the work carried out at the start of this unit. They should account for these properties using the kinetic theory of matter. Students should explain a variety of terms relating to the liquid state including: • Boiling – change from a liquid to a gas at a definite temperature, the boiling point of the liquid • Condensation – change from a gas to a liquid at the boiling point of the liquid • Molar heat of vaporisation – the amount of heat needed to convert 1 mole of a liquid at its boiling point to a gas (the same amount of energy that is released when 1 mole of vapour at the condensing point of a vapour condenses to become liquid) • Molar heat of condensation - the amount of heat realised when 1 mole of a gas is converted to a liquid at its condensation point • Evaporation – change of a liquid to a gas at any temperature. Students should discuss the differences between boiling and evaporation: • boiling is at a fixed temperature and occurs throughout a liquid • Evaporation is at any temperature and occurs only at the surface of a liquid Students should be able to explain vapour pressure and identify	Check students' performance and give feedback Monitor the discussion and give summary

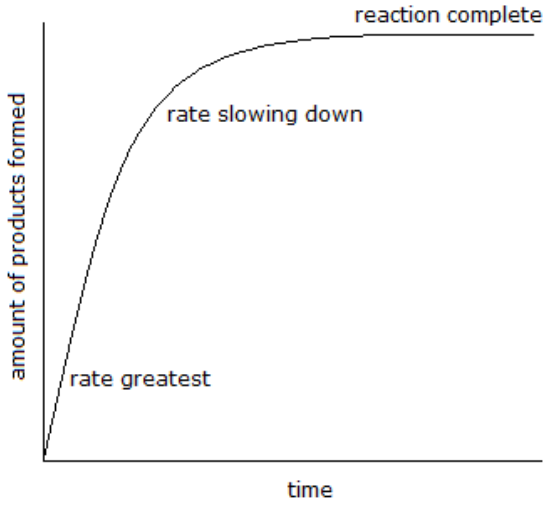
Competencies	***Contents***	***Suggested Activities***	***Assessment***
demonstrate the concept of vapour pressure	point of a liquid	that a liquid boils when its saturated vapour pressure becomes equal to atmospheric pressure	Guide students, observe students' activities and give feedback
• Carry out an activity to determine the boiling points of water and ethanol		Students should carry out an experiment to demonstrate vapour pressure by connecting a round-bottomed flask with bung and delivery tube, containing some liquid, to a manometer. As the liquid is warmed the vapour pressure increases and this is detected by the manometer. Students should quantify the above experiment and collect data which could then be analysed. Students should carry out an experiment to measure the boiling points of water and ethanol just above the surface of the liquids as they boil. Students could discuss why the thermometer y should not be placed in the boiling liquid – superheating.	Observe students' activities and give feedback
• Explain the terms melting, fusion, sublimation, melting point, freezing point, molar heat of fusion and molar heat of solidification.	**3.6. The solid state** *(2 periods)* • Melting • Freezing • Energy changes in melting and freezing • Sublimation	Students should describe the simple properties of solids from the work carried out at the start of this unit. They should be able to account for these properties using the kinetic theory of matter. Students should explain a variety of terms relating to the solid state including: • Melting (fusion) – change from a solid to a liquid at a definite temperature, the melting point of the solid • Freezing (solidification) – change from a liquid to a solid at the freezing point of the liquid	Check students' performances and give feedback Observe students' activities and give feedback Check students'
• Describe phase changes. • Explain temperature changes associated with phase changes			

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Determine melting point of ice. • Demonstrate an experiment to show the phase changes from ice to liquid water and then to water vapour	• Determination of melting point. Phase changes	• Molar heat of fusion – the amount of heat needed to convert 1 mole of a solid at its melting point to a liquid (the same amount of energy that is released when 1 mole of liquid at the freezing point of a liquid freezes to become solid • Molar heat of solidification - the amount of heat released when 1 mole of a liquid is converted to a solid at its freezing points. • Sublimation – change directly from solid to gas without going through the liquid phase or the reverse i.e. the direct change from a gas to solid Students could measure the melting point of ice by placing a thermometer in a funnel containing melting ice, suspended about a beaker. Students should round off the unit by discussing phase changes. Students should carry out experiments in which they: • Convert ice to water • Convert water to steam • Convert steam to water • Convert water to ice Students should name the processes involved and state which are exothermic (give out heat), and which are endothermic (take in heat). Students should discuss some of the practical implications of phase changes e.g. why does a burn from steam at 100 °C more damaging to the skin than a burn from water at 100 °C?	performance and give feedback Monitor the discussion and give feedback

Unit 4: Chemical kinetics *(9 periods)*

Unit outcomes: Students will be able to:

- Explain the rate of a chemical reaction
- Describe the preconditions for a reaction to occur
- Discuss the factors affecting the rate of chemical reactions
- Demonstrate scientific inquiry skills: observing, classifying, comparing and contrasting, inferring, predicting, communicating, measuring, asking questions, interpreting data, drawing conclusion, applying concepts, relating cause and effect and problem solving.

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Students will be able to: Define a reaction rate Describe a reaction rate using graphs	**4.1 Rate of chemical reaction (***3 periods***)** • Reaction rate	Students should define that the rate of a reaction is the rate at which reactants are converted to products. Students could discuss different ways in which the rate of a reaction can be monitored. These could include: • Change of colour • Volume of gas evolved • Amount of precipitate formed • Loss or gain of mass Students should draw a graph showing how the rate of a chemical reaction changes over time and relate the rate to the slope of the graph.  	Check students' performance Monitor the discussion and give feedback Observe students' performance and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Conduct an experiment to illustrate the relative rate of reactions		Students should carry out experiments to study how the rate changes during a chemical reaction. These could include: • Metal + dilute acid e.g. zinc + dilute sulphuric acid • Metal carbonate + dilute acid e.g. calcium carbonate + dilute hydrochloric acid In both of these types of reaction the rate can be monitored by: • Measuring the loss of mass over time • Measuring the volume of gas produced over time	Observe students' activities and provide feedback
•List the preconditions for a chemical reaction to occur	•Preconditions for a chemical reaction	Students should list down the preconditions for a chemical reaction to occur – collision, activation energy and proper orientation	Check students' performance and give feedback
• Explain how collision, activation energy and proper orientation of reactants are a preconditions for a chemical reaction to occur		Students should describe that in order for a chemical reaction to take place the reacting particles must collide with each other with sufficient force – an effective collision. Students should discuss how providing reacting particles with activation energy: • Increases the kinetic energy of the particles • Increases the chances that collisions between particles will be effective	Monitor the discussion and give summary
• List factors that affect rate of chemical reaction	**2.4 Factors affecting rate of chemical reaction** *(6 periods)*	Students should identify that the rate of a chemical reaction depends on: • Nature of reactants • Temperature • Concentration or pressure • Surface area	Check students' performance and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Describe the effect of changes in temperature, concentration or pressure and surface area on the rate of a chemical reaction • Explain the effect of catalysts on the rate of chemical reaction • Do an activity on how the factors affect the rate of chemical reaction		• Use of a catalyst Students should discuss these factors in terms of collision theory. This could include: • Temperature – an increase in temperature increases the kinetic energy of the reacting particles so there is a greater chance of collisions being effective • Concentration or pressure – increasing the concentration (of reacting solutions) or pressure (of reacting gases) increases the chances of particles colliding with each other as there will be more particles per unit volume • Surface area – increasing the surface area of a solid reactant increases the chances of collisions with the other reactant • Use of a catalyst – a catalyst reduces the activation energy so particles collisions can be effective at lower temperatures Students should investigate the effects of each of these factors experimentally e.g. • Temperature – metal-acid reaction using acid of different temperatures • Concentration – metal-acid reaction or metal carbonate-acid reaction using acid of different concentrations • Surface area – zinc-acid reaction using granulated zinc and zinc powder; calcium carbonate-dilute hydrochloric acid using chippings and powdered calcium carbonate • Catalyst – decomposition of hydrogen peroxide using manganese (IV) oxide	Monitor the discussion, check students' performance and give summary Guide the students and observe their performance Provide feedback

Unit 5: Chemical Equilibrium *(16 periods)*

Unit outcomes: Students will be able to:

- Discuss how equilibrium is established;
- Explain characteristics of dynamic equilibrium;
- State the law of mass action and write an expression for equilibrium constants, $K_{c\ and}$ K_p, from a given chemical reaction;
- Apply the law of mass action to calculate K_c , K_p, concentration and pressure of substances in equilibrium;
- Explain how the reaction quotient is used to indicate position of the equilibrium;
- State Le-Chatliers' principle and use it to predict and explain the effects of changes in temperature, pressure, concentration and presence of a catalyst on a reaction;
- Perform an activity to demonstrate the effects of changes in concentration on the position of equilibrium and to determine Kc or K_p values;
- Explain how equilibrium principles may be applied to optimize the production of industrial chemicals (e.g. production of ammonia and sulphuric acid);
- Describe scientific enquiry skills along this unit: observing, predicting, comparing & contrasting, communicating, asking questions and making generalization.

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Students will be able to: • explain reversible and irreversible reactions • define dynamic chemical equilibrium • state the necessary conditions for attainment of equilibrium • describe the microscopic event that occur when a chemical system is in equilibrium • explain the characteristics of chemical equilibrium • state the law of mass action • define equilibrium constant • write the equilibrium constant expression for chemical reactions that	***5. Chemical Equilibrium*** **5.1 Introduction** *(1 periods)* **5.2 Chemical Equilibrium** *(15 periods)* • Reversible and irreversible reactions • Attainment and characteristics of chemical equilibrium • Equilibrium expression and equilibrium constant - The law of mass action	Students should define chemical equilibrium and explain the definition with the help of examples Students should identify that chemical equilibrium applies only to reversible chemical reactions and is a dynamic one (not static), that what remain unchanged in a chemical reaction at equilibrium are the rates of both the forward and reverse reactions and that they are equal; hence no shift in position of equilibrium, concentrations of reactants and concentration of products remain the same (but concentration of reactants are not necessarily equal to concentration of products; if they are it is mere coincidence) Students should identify that there is a simple relationship between the concentrations of reactants and products in an equilibrium system. The relationship between mass action expression, reaction quotient and equilibrium constant has to be discussed by students. They should identify that the equilibrium constant is a special reaction quotient which itself is a numerical value of mass action expression that is determined when the system is at equilibrium. The use of reaction quotient in relation to the equilibrium	Check students' performance and give summary Monitor the discussion and give summary Guide the discussion and give summary

Competencies	***Contents***	***Suggested Activities***	***Assessment***
involve concentration • calculate values for equilibrium constant involving concentration • state the relationship of K_{eq} to the relative amounts of products and reactants in a given reaction • write the equilibrium constant expression for chemical reactions that involve partial pressure; • calculate values for equilibrium constant involving partial pressure; • show the relationship between K_C and K_P • distinguish between homogeneous and heterogeneous equilibrium reactions;	- Equilibrium constant expression involving concentration, K_C - Equilibrium constant expression involving partial pressure, K_P - Equilibrium constant for heterogeneous reaction	constant, as an indicator which way a reaction will go to reach equilibrium, has to be discussed. Applications of the equilibrium constant in determining the composition of the equilibrium mixture needs highlighting. Students should explain that at equilibrium, at a given temperature, the mass action expression for a given reaction is always equal to the same number, the equilibrium constant. Remember, there are no restrictions on the individual equilibrium concentrations. The only requirement is that when they are substituted into the mass action expression, the resulting fraction must equal the equilibrium constant. For the general reaction $aA + bB \leftrightarrow mM + nN$ the mass action expression is: $$\frac{[M]^m [N]^n}{[A]^a [B]^b} = K_c$$ Where Kc is equilibrium constant, when all concentrations are equilibrium concentrations. Students should show that for reactions involving gases, partial pressures can be used in place of molar concentrations. Remember the relationship $K_p = K_c(RT)^{\Delta n}$ which is used to interchange K_p and K_c. Δn is change in the number of moles of gases. Students should explain that in heterogeneous reactions the reactants and products are not all in the same phase. The concentrations of pure liquid and solid are not included in the	Check students' performance and give feedback Check students' activities and give feedback Listen students' responses and give summary

Competencies	***Contents***	***Suggested Activities***	***Assessment***
		mass action expression of the heterogeneous reactions. This is because they are constant and are included in the equilibrium constant.	
• define reaction quotient • use the equilibrium quotient to predict the direction of the reaction and the position of equilibrium • calculate equilibrium concentrations given initial concentrations • determine whether the reactants or products are favored in a chemical reaction given the equilibrium constant; • list factors that affect chemical equilibrium • state Le-Chatliers principle • use Le-Chatliers principle to explain the effect of changes in temperature,	- Reaction quotient (Q_C) - Predicting the direction of reaction - Applications of equilibrium constant - Predicting the position of equilibrium mixture - Calculating the equilibrium concentrations of reactants and products • Changing equilibrium conditions: Le-Chatleries principle	Students should identify that reaction quotient, Q_C, is the numerical value of the mass action. It is used to predict whether a reaction has reached or not and if it has not which direction it will proceed. If $K_c = Q_C$, system is at equilibrium, $K_c < Q_C$, reaction proceeds toward reactants and $K_c > Q_C$, reaction proceeds toward products. There are basically two kinds of calculations that students have to learn. One is to calculate K from either equilibrium concentrations or information from which you can deduce equilibrium concentrations. The other is to calculate information about equilibrium concentrations, given the value of K. Students should be given exercises until they become conversant. Students should explain the concepts behind the mathematical manipulation of equilibrium problems. Students should define the Le Chatelliers principle. Students should discuss that after new equilibrium is established right after subjecting a system in equilibrium to stress, the equilibrium constant remains unchanged but the individual	check students' performance and give feedback Check on a sample exercises and give feedback Monitor the discussion and give summary

Competencies	***Contents***	***Suggested Activities***	***Assessment***
pressure, concentration and presence of catalyst on a reaction; • state the effect of changes in concentration, pressure/volume and temperature on K_{eq}	• Equilibrium and Industry - Equilibrium in the Haber process - Equilibrium in the contact process	concentrations of reactants and products could change. The point that, equilibrium constant for a given reaction changes only with temperature but not with concentration or pressure of reactants/products has to be explained by students. Students should discuss the application of Le Chatelier's principle in industrial production of important substances such as ammonia and sulfuric acid. • When a reactant or product is added to a system at equilibrium, the position of equilibrium shifts toward the opposite side of the equation. • Decreasing the concentration of a reactant or product causes the position of equilibrium to shift in the direction of the substance removed. • Increasing the pressure by decreasing the volume shifts the position of equilibrium in the direction of the fewest number of moles of gas. • An increase in temperature causes the position of equilibrium to shift in the direction of the endothermic reaction. • A decrease in temperature causes the position of equilibrium to shift in the direction of the exothermic reaction. • A very important point to remember is that the only thing that changes K for a reaction is a change in temperature‼ • Adding an inert (unreactive) gas to a system, without changing the volume, has no effect on the position of equilibrium. • A catalyst has no effect on the position of equilibrium. It only increases the speed with which the system reaches equilibrium.	Monitor the discussion and give summary
• perform an activity to demonstrate the effect of changes in concentration on the position of equilibrium		Students should perform activities to demonstrate the effects of changes	Observe student' activities and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• perform an activity to demonstrate the effect of changes in temperature on the position of equilibrium • Perform an activity to determine K_C for esterification of an organic acid • define optimum conditions • explain how Le-Chatliers principle is applied - in the Haber process (production of NH_3) - in the Contact process (production of H_2SO_4)		-In concentration on the position of equilibrium. Eg. Take 0.01M, 0.02M, 0.03M and 0.04M $Fe(NO_3)_3$ (aq) to react with 0.01M KSCN(aq) -In temperature on the position of equilibrium. Eg. The reaction between iodine, I_2 and starch Students could perform activities to determine equilibrium constant. Eg. Kc for esterification of an organic acid Students should explain that chemical equilibrium along with Le Chatelier's principle has applications in industrial production of important substances. Students should describe that in order to optimize production of ammonia in the Haber process and sulfuric acid in the contact process, chemists or chemical engineers exploit fully the principles in this unit.	Check students' performance and give feedback

Unit 6: Some important organic compounds *(20 periods)*

Unit outcomes: Students will be able to:

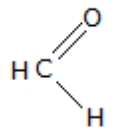
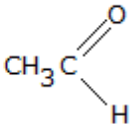
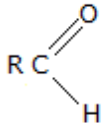
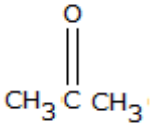
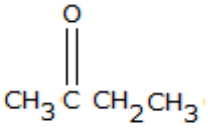
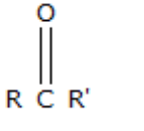
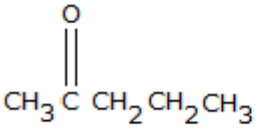
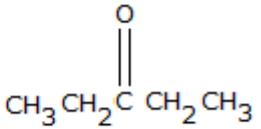
- Give the general formulas of alcohols, aldehydes, ketones, carboxylic acids, esters, anhydrides, amides, and acid chloride;
- Develop skills in naming and writing the molecular and structural formulas of alcohols, aldehydes, Ketones, carboxylic acids esters, anhydrides, amides, and acid chloride
- Write the structural formula and IUPAC names of given alcohol, aldehyde, ketones, carboxylic acids, and esters;
- Describe some physical and chemical properties of carboxylic acids and esters;
- Predict and correctly name the products of organic reactions, including substitution, addition, elimination, esterification, hydrolysis and oxidation reactions;
- Carry out activities to prepare a carboxylic acid and an ester;
- List some important fatty acids;
- Test for the carboxylic acid and ester functional groups;
- Give the structures, properties and uses of fats and oils;
- Describe scientific enquiry skills along this unit: observing, classifying, comparing & contrasting, asking questions, drawing conclusion, applying concepts and problem solving.

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Students will be able to: • Classify organic compounds	**6.1. Introduction** *(1 period)* • Classification of organic compounds	Students should identify that organic compounds are classified into groups on the basis of a functional group. It is the functional group in a molecule that determines much of the chemistry of a compound.	Check students' performance and give feedback
• Define alcohols • Tell the functional group of alcohols. • Give the IUPAC names for given alcohols. • Classify alcohols based on the number of hydroxyl (OH^-) groups. • Write the general formula of monohydric alcohols • Write the molecular formulas and the names of the first six members of monohydric alcohols	**6.2. Alcohols and ethers** *(6 periods)* • Classification and nomenclature of alcohols	Students should describe that the alcohols are a homologous group of organic chemicals which have the general structural formula R-OH, where R= alkyl or aryl group. The functional group in alcohols is –OH and the suffix used to denote this group is an 'ol'. Students could use the prefixes given in a previous section together with the suffix an' ol' to name the first six alcohols in the series. Students should explain that alcohols can be classified on the basis of the number of hydroxyl groups in the molecule. These are described as: • Monohydric e.g. ethanol CH_3-CH_2-OH • Dihydric e.g. ethane-1,2- diol HO-CH_2-CH_2-OH • Trihydric e.g. propane-1,2,3-triol HO-CH_2-CH OH- CH_2-OH Students should identify that monohydric alcohols have the general formula $C_nH_{2n+1}OH$ Students could apply the general formula to find the molecular formulas of the first six members of monohydric alcohols	Check on a sample exercises and give feedback

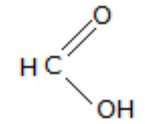
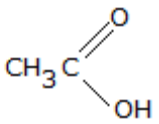
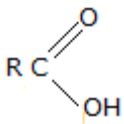
Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Classify monohydric alcohols based on the number of alkyl groups attached to the carbon atom carrying the hydroxyl group • Give some examples for primary, secondary and tertiary alcohols	• Classifications of monohydric alcohols	Students should discuss that alcohols can be classified according to the nature of the groups attached to the carbon atom which carries the hydroxyl group: • Primary alcohols – the carbon carrying the hydroxyl group is attached to only one alkyl group (and two hydrogen atoms) RCH_2OH • Secondary alcohols – the carbon carrying the hydroxyl group is attached to two alkyl groups (and one hydrogen atom) RR'CHOH • Tertiary alcohols – the carbon carrying the hydroxyl group is attached to three alkyl groups (and no hydrogen atoms) RR'R''COH	Monitor the discussion and give summary
• Give the structural formula of monohydric alcohol		Students should draw the structure of alcohols and state whether they are primary, secondary or tertiary alcohols.	Check on a sample exercises and give feedback
• Describe the physical properties of alcohols	• Physical properties	Students should explain that: • the hydroxyl group in an alcohol is polar due to the high electro negativity of oxygen: $-O^{\delta-}-H^{\delta+}$ • as a result of this there is significant hydrogen bonding in alcohols • the melting points and boiling points of alcohols are much higher than those of alkanes of similar relative molecular mass • even the first alcohol in the series, methanol, is a liquid at room temperature Students could compare the boiling points of ethanol (RMM = 46) and propane	Listen students' performance and provide summary

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Explain general methods of preparation of alcohols • Explain the industrial preparation of ethanol • Perform an activity to prepare ethanol from sugar	• Preparation	(RMM = 44) In the laboratory alcohols can be made by a number of different routes including: • Hydrolysis of alkyl halides by heating with sodium hydroxide solution R-Cl + NaOH → R-OH + NaCl • Hydrolysis of esters by heating with potassium hydroxide solution R-COO-R' + KOH → R-COOK + R'-OH These are both examples of replacement reactions since different groups are replaced by –OH. Students should explain that there are two main industrial processes for the manufacture of ethanol: • the fermentation of carbohydrates such as sugars $C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$ • the hydration of ethene with steam at 573 K and 60 atmospheres in the presence of a phosphoric acid catalyst Students should prepare a small sample of ethanol by fermentation followed by distillation.	Listen students' responses and give feedback Observe students activity and give feedback
• Explain the chemical reactions of alcohols such as oxidation, reaction with active metals, esterification	• Chemical properties	Students should explain that alcohols can be oxidised using suitable reagents such as acidified potassium manganate(VII) solution or acidified potassium dichromate solution. The nature of the oxidation product depends on whether the	Listen students' responses and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
and dehydration. • Carryout an activity to show chemical reaction of alcohols with active metal • Write the molecular formulas and names of the first six members of ethers • Give the IUPAC names for given ethers • Describe the physical properties of ethers • Explain the general methods of preparation of ethers • Explain the use of ethers such as solvent in organic reactions • Write the general structural formula of aldehydes • Write the molecular formulas and names of simple aldehydes	• Ethers -Structure and Nomenclature of Ethers -Physical Properties of Ethers -Preparation of Ethers -Reactions of Ethers **6.3. Aldehydes and Ketones (2 periods)** - Structure and Nomenclature	alcohol is primary, secondary or tertiary. • Primary alcohols are oxidised to form aldehydes $R\text{-}CH_2\text{-}OH + [O] \rightarrow R\text{-}COH$ • Students should carry out some experimental activities to investigate properties of alcohols • Students should write the molecular formula and name the first six members of ethers • Students describe the physical properties of ethers and compare with alcohols and hydrocarbons Students should write the general formula of aldehydes Aldehydes are named on the basis of the number of carbon atoms present and the suffix 'anal'.	Observe students' activity and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Write the general structural formula of ketones • Write the molecular formulas and names of simple ketones		 methanal  ethanal  general formula of an aldehyde Students could draw and name the aldehydes up to those containing six carbon atoms. Ketones are named on the basis of the number of carbon atoms present and the suffix an 'one'.  propanone  butanone  general formula of a ketone Students should identify that with large numbers of carbon atoms it is necessary to identify the carbon atom which is bonded to the oxygen atom.  pentan-2-one  pentan-3-one (2-pentanone) (3-pentanone)	Check students' performance and give feedback Check students' performance and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Describe the physical properties of aldehydes and ketones • Explain the general methods of preparation of aldehydes and ketones • Explain the chemical reactions of aldehydes and ketones such as addition, oxidation and reduction	-Physical properties of Aldehydes and Ketones -Method of preparation of aldehydes and ketones -Reactions of aldehydes and ketones (addition, oxidation, and reduction)	Students could draw and name ketones up to those containing six carbon atoms. Students should explain why aldehydes and have higher boiling points than those of nonpolar compounds with comparable molecular weight. Students should describe the preparation of aldehydes and ketones by ozonolysis alkenes and oxidation of alcohols • Ozonolysis of alkenes give aldehydes and ketone R-CH=CR'R'' → RCHO + R'COR'' • Primary alcohols are oxidized to form aldehyde, but further oxidized to carboxylic acid $R\text{-}CH_2OH + [O] \rightarrow R\text{-}CHO \rightarrow R\text{-}COOH$ • Secondary alcohols are oxidised to form ketones R-CHOH-R' + [O] → R-CO-R' Students should discuss addition of Grignard reagents and alcohols to aldehydes and ketones Students should explain oxidation and catalytic reduction of aldehydes and ketones	Check students' performance and give feedback Check students' performance and give feedback Check students' performance and give feedback
• List common organic acids and mention their sources; • Write the general formula of saturated monocarboxylic acids;	6.4. Carboxylic acids (5 periods) • Nomenclature and structure	Students should explain that the carboxylic acids are a homologous group of organic chemicals which have the general structure R-COOH. The functional group in carboxylic acids is -COOH and the suffix used to denote this group is an 'oic acid'. Students should list the common sources of carboxylic acids. You could motivate the students if you relate common names of some carboxylic acids to the source they were isolated from	Check students' performances and provide feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Write the molecular formulas and names of the first six members of saturated monocarboxylic acids; • Give the structural formula for the first four members of saturated mono carboxylic acids. • Give examples for mono carboxylic, dicarbcxylic and tricarboxylic acids; • Name some branched carboxylic acids;		initially. Example is butyric acid from rancid butter. Students could use the prefixes given in a previous section together with the suffix 'anoic acid' to name the first six carboxylic acids in the series.  methanoic acid  ethanoic acid  general formula of a carboxylic acid Students should give examples' of monocarboxylic, dicarboxylic, and tricarboxylic acids Students should give the IUPAC nomenclature for branched carboxylic acids. Even though IUPAC should be at the center of nomenclature, it is useful to introduce the α,β,γ,δ…position of attachment. Students should identify that the carboxyl carbon is always considered as C-1, and hence C-2 corresponds to α of the common names, C-3 to β, and so on. (Caution: Do not mix Greek letters with IUPAC names, or Arabic numerals with common names.) Hence the α-carbon is the one bearing the carboxyl group. This is commonly used in biochemical literature. γ β α C-C-C-COOH (used in common names) Students should describe the structural differences between the aromatic carboxylic acids and aliphatic acids with phenyl ring	Check students' performance and give feedback Listen students' responses and

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• describe the physical properties of saturated mono carboxylic acids Describe the chemical	• Physical properties • Chemical properties	substituents. The aromatic acids are usually named as derivatives of the parent acid, benzoic acid, C6H5COOH. Students should list down some physical properties using the chemical knowledge they have mastered so far. You might hint that properties of molecules follow structure, to the students at this point and see how this might help them. • Solubility: Carboxylic acids have two distinct parts in terms of associating with water. Ask the students to identify them. They could discuss this in groups. The hydrocarbon part is hydrophobic whereas the carboxyl group is hydrophilic. The aliphatic acids, therefore, show very much the same solubility behavior as the alcohols: the first four or five are miscible with water and the higher acids are virtually insoluble. Water solubility undoubtedly arises from hydrogen bonding between the carboxylic acid and water. The simplest aromatic acid, benzoic acid, contains too many carbon atoms to show appreciable solubility in water. Carboxylic acids are soluble in less polar solvents like ether, alcohol, benzene, etc. • Boiling Point: As a class the carboxylic acids are even higher boiling than alcohols. For example propionic acid (b.p. 141 °C) boils more than 20 °C higher than the alcohol of comparable molecular weight, n-butyl alcohol(b.p. 118 °C). These very high boiling points are due to the fact that a pair of carboxylic acid molecules are held together not by one but by two hydrogen bonds. Students draw structure of two carboxylic acids with two intermolecular H-bonds between them. • Odor: Students should list down odors of some carboxylic acids that they might have encountered in laboratories or elsewhere.	give feedback Monitor the discussion and give feedback Check on a sample exercises and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
properties of carboxylic acids • explain the chemical properties of saturated mono carboxylic acids		Students should discuss that the characteristic chemical behavior of carboxylic acids is, of course, determined by their functional group, carboxyl, -COOH. This group is made up of a carbonyl group (C=O) and a hydroxyl group (-OH). It is the –OH that actually undergoes nearly every reaction-loss of H+, or replacement by another group-but it does so in a way that is possible only because of the effect of the C=O. The most important chemical property of carboxylic acids is their acidity. They form salts when treated with strong bases like OH- and even with weaker bases such as HCO3- and NH3. The rest of the molecule undergoes reactions characteristic of its structure; it may be aliphatic or aromatic, saturated or unsaturated, and may contain a variety of other functional groups.	Monitor the discussion and provide feedback
• explain the general methods of preparation of saturated mono carboxylic acids;	• Preparation	Students should explain preparation of carboxylic acids. You may pick few appropriate chemical reactions to illustrate their preparations. 1. Oxidation of Primary alcohols $R\text{-}CH_2OH \xrightarrow{KMnO_4} R\text{-}COOH$ 2. Oxidation of alkyl benzenes $Ar\text{-}R \longrightarrow Ar\text{-}COOH$	Check on a sample exercises and give feedback
• explain the industrial and		Students should explain the industrial and laboratory preparations of acetic acid.	Observe students' performance and

Competencies	***Contents***	***Suggested Activities***	***Assessment***
laboratory preparation of acetic acid. • Conduct an experiment to prepare acetic acid in the laboratory • explain why "tella" or "tej" turns sour. • Name and write structural formulas of some fatty acids. • describe some uses of common carboxylic acids	• Fatty acids • Uses	Students should prepare acetic acid in the laboratory Let students to discuss why “tella” or “tej” turns sour in few days after preparation Students should identify fatty acids are carboxylic acids with a long hydrocarbon chain that are found in all cells. The hydrocarbon chains of animal fatty acids are more saturated than those of vegetable origin. With only a few exceptions, the fatty acids are all straight-chain compounds. Most fatty acids contain an even number of carbon atoms. Let the students mention some uses of common carboxylic acids like acetic acid	give feedback Monitor the discussion and give feedback
• list common sources of esters; • write the general structural formula of esters • write the molecular formulas and names of some simple esters	6.5. Esters (4 periods) • Sources of esters • Nomenclature	Students should identify that esters are found abundantly in living organisms. Students should explain that an ester is made by replacing the H of an –OH acid with an R group. Carboxylic esters derived from carboxylic acids, therefore, have the formula RCOOR’. They are named as derivatives of the corresponding carboxylic acids, and the best way to begin is by 1. Naming the acid, using either the IUPAC name or the common name. 2. After that, the procedure is the same as for naming salts. The “-ic acid” is changed to “ate,” and this word is the second word in the ester name. 3. The first word is the name of the R’ group.	Check students’ performance and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• describe physical properties of esters,	• Physical properties	E.g CH3-C-O-CH2CH3 ‖ O 1. Name of acid: Ethanoic acid or acetic acid 2. Change "-ic acid to "ate,": Ethanoate or Acetate 3. Name of R' comes first: Ethyl Hence full name is: Ethyl ethanoate or Ethyl acetate. Students should give names for few common carboxylic esters. (Remember there are inorganic esters like phosphoesters as well.) You may ask them also to identify the acid and alcohol (or phenol) portions of these carboxylic esters. Boiling points: Students should identify whether esters will have higher, lower or similar boiling points compared to compounds of comparable molecular mass that do form hydrogen bonds. Because ester molecules cannot form hydrogen bonds with each other, esters have lower boiling points than compounds of comparable molecular mass that are capable of forming hydrogen bonds. Solubility: Since carboxylic esters can form hydrogen bonds with water, it is not surprising that their solubility in water is about the same as that of carboxylic acids of the same molecular	Check students' performance and give feedback Check students' performance and give feedback

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• explain the chemical properties of esters; • Explain the general methods of preparation of esters • describe some uses of common esters;	• Chemical properties • Preparation • Uses	weight. Odor: In sharp contrast to the disagreeable odors of carboxylic acids, esters have pleasant odors. Many of the odors of fruits and flowers result from mixtures of carboxylic esters, and many of them are used in perfumes and food flavorings. Students should identify that the most important reaction of carboxylic esters is their hydrolysis, which may be catalyzed by either acids or bases. For synthetic purposes, base catalysis is often preferred because the reaction is not reversible. Base catalyzed ester hydrolysis is called saponification. In biological systems, ester hydrolysis is catalyzed by enzymes. Students should explain preparation of esters. Carboxylic esters can be considered as a combination of a carboxylic acid and an alcohol (or phenol). In fact, they can be synthesized by heating a mixture of a carboxylic acid and an alcohol in the presence of an acid catalyst such as H2SO4. Students should describe that esters have numerous uses: - Solvent - Medicine - Clothing eg polyesters (Dacron) - Fragrance in perfumes - Plasticizers eg octyl phthalate Students should gather information on carboxylic acid	Check students' performance and give feedback Check students' performance and give feedback Give a project work to students and evaluate their work

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• Write the general structural formula of amides, acid halides and anhydrides • Give IUPAC name of amides, acid halides and anhydrides • describe physical properties of amides, acid halides and anhydrides • Discuss the common chemical reactions and methods of preparations for amides, acid halides and anhydrides	Structural formula of derivatives of carboxylic acids such as amides, acid halides and anhydrides Nomenclature Physical properties Chemical reactions and methods of preparations	derivatives (amides, acid chloride, and anhydrides) from different sources, compile and present. This includes structural formula, naming, physical properties, chemical reactions, and methods of preparations).	Listen students' responses and give summary
• define fats and oils • write the general structural formula for fats and oils • write the structures of some common triglycerides	6.6. Fats and Oils (2 periods) • Structure	Fats and oils are esters. Students should explain that they are widely found in nature especially in living things as esters of glycerol, in fact triacylglycerols. Fats and oils are triacylglycerols whose hydrocarbon tails, derived from carboxylic acids, are long enough to make them hydrophobic. As the hydrocarbon tail gets longer, they become more fatty i.e less water soluble. The degree of unsaturation of the fatty acid tail portion of triacylglycerol is responsible for the physical states of the fats and oils.	Observe students' performance and give feedback
• describe physical properties of fats and		Students should explain that animal fats are generally solids at room temperature and those from plants are usually liquids	

Competencies	***Contents***	***Suggested Activities***	***Assessment***
oils • explain hardening of oils (process of converting oils to hard fats)	• Physical properties • Hardening of oils	(oils). Warn students not to confuse the edible vegetable oils with mineral oils which are entirely different; mineral oils (petroleum) which are long chains of alkanes. Students should discuss how hydrogenation of vegetable oils results in the formation of solid fat (eg SHENO LEGA) which is not different in composition from animal fat. Students identify if it is OK to consume Sheno Lega during fasting season. Students should show how to calculate oxidation numbers of the various carbon atoms in both fats and oils and use oxidation number as an indicator of energy content; the lower the oxidation number the higher the energy content of the substance. Reference could also be made to the type of hybridization of the carbon atoms. Vegetable oils differ from animal fats in possessing higher degree of unsaturation, but could have double bonds. Students should identify that numerous fats contain sites of unsaturation like vegetable oils. Students should discuss why unsaturation in fat tends to lower its melting point and thus tends to make it a liquid at room temperature. Hydrogenation of some of the double bonds in oils converts these liquids into solids having a consistency comparable to that of butter. The accompanying change of state is called hardening of oils. Students should explain that hydrogenation not only changes the physical properties of a fat, but also-and this even is more	Monitor the discussion and give summary Check students' performance and give feedback Check students' performance and give feedback Monitor the discussion and give feedback Listen students' responses and provide summary

Competencies	***Contents***	***Suggested Activities***	***Assessment***
• explain rancidity	• Rancidity	important-changes the chemical properties. Students should discuss why a hydrogenated fat becomes rancid much less readily than does a non-hydrogenated fat. Students should explain why fats and oils become rancid if left un refrigerated. Students should also discuss why Mothers treat butter (animal fat) by heating it to boiling? And what is going on during the heat treatment?	

Chemistry Syllabus

for Grade 12

General Objectives of Grade 12 Chemistry

To develop understanding and acquire knowledge of:

- different concepts of acids and bases, their properties and qualitative and quantitative expressions;
- energy changes in physical and chemical processes and laws governing them;
- fundamental concepts related to the interconversion of chemical and electrical energy;
- qualitative and quantitative aspects of electrochemistry and its applications;
- occurrence, abundance and metallurgical processes of some useful elements;
- analyzing the risks and benefits of the development and application of synthetic polymers and suggesting possible methods of control.

To develop skills and abilities of:

- solving equilibrium problems involving acids and bases;
- predicting weather a solution of a specific salt will be acidic, alkaline or neutral;
- calculating energy changes in chemical reactions;
- determining spontaneity of chemical reactions;
- calculating problems related to electrolysis;
- constructing model galvanic cell;
- designing and conducting simple experiments relevant to their level.

To develop habits and attitudes of:

- appreciating the roll of some chemical processes such as buffer systems in balancing natural phenomena in our lives;
- practicing the chemical and physical methods of preventing corrosion;
- realising that elements are cycling in nature;
- being confident and independent;
- relating a scientific knowledge to everyday applications.

Unit 1: Acid-base Equilibria *(32 periods)*

Unit outcomes: *Students will be able to:*

- describe the draw backs of Arrhenius,
- define Bronsted-Lowery & Lewis concepts of acids & bases;
- describe the dissociation of water, weak mono-protic & polyprotic acids, & weak bases;
- explain how to solve equilibrium problems involving concentration of reactants & products, ka, kb, PH& POH;
- discuss the common ion effect, buffer solution, hydrolysis of salts, acid-base indicators and acid-base titrations;
- explain how buffering action affects our daily lives using examples;
- determine the equivalents of acid or base that are required to neutralize specific amount of acid or base;
- predict, in qualitative terms, whether a solution of a specific salt will be acidic, basic or neutral;
- explain how to solve problems involving concentration and PH of acid-base titration;

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Students will be able to: • state acid by the Arrhenius concept • explain why proton exists bounded to water molecule , as H_3O^+, in all acid-base reactions; • give examples of Arrhenius acids • define base by the Arrhenius concept • give examples of Arrhenius bases; • define acid by the Bronsted-Lowry concept; • give examples of Bronsted-Lowry acids • define base by the Bronsted-Lowry concept • give examples of Bronsted-Lowry bases. • explain what conjugate acids and conjugate bases are • identify the acid-base conjugate pairs from the given reaction;	***1. Acid-base Equilibria*** **1.1 Acid-base concepts** *(5 periods)* • Arrhenius concept of acids and bases • Bronsted-Lowry concept of acids and bases - Conjugate acid-base pairs - Auto ionization of substances - Amphiprotic species	• Students should define the terms acids and bases according to Arrhenius, Bronsted-Lowry and Lewis\ • Students should describe why proton exists bound to water molecule's, as H_3O^+, reactions involve acid-base • Students should define some terms like conjugate acid-base pair, auto ionization and amphiprotic species under Bronsted-Lowry concepts. • Students should give examples of Arrhenius, Bronisted-Lowry and Lewis acids and identify conjugated acid – base pairs • Students should identify that the most general theory of acids and bases is that of Lewis. This theory encompasses the Bronsted-Lowry theory, and it goes one step further by describing acid-base behavior to many reactions that do not involve the transfer of a proton • Students should discuss one direction in which the science of chemistry matured, as narrow definitions of acids and bases progressively widened to encompass different species, physical states, solvent systems and reaction types.	Listen student's response and give feed back Give Sample exercise and give feed back Monitor the discussion and give feedback

• Write an equation for self-ionization of water and ammonia. • explain what is meant by amphiprotic species • give examples of reactions of amphiprotic species; • define acid by the Lewis concept • give examples of Lewis acids • define base by the Lewis concept • give examples of Lewis bases • calculate pH from $[H^+]$and $[H^+]$ from pH • calculate pOH from $[OH^-]$ and $[OH^-]$ from pOH	• Lewis's concept of acids and bases		
• describe the ionization of water • drive the expression of ion product for water, K_W • explain the effect of temperature on Kw • explain why water is a weak electrolyte • use Kw to calculate $[H_3O^+]$ or $[OH^-]$in aqueous solution	**1.2 Ionic Equilibria of weak acids and bases (9 *periods)*** **Ionization of water** - Ion product for water, K_W • Measures of the strength of acids and bases in aqueous solution; - H^+ ion concentration, $[H^+]$, and OH^- ion concentration , $[OH^-]$	• Students should explain that equilibria involving the ionization of weak acids and weak bases in aqueous solution are very important in many fields of science. • Students should describe that in any solution in which water is the solvent, the equilibrium condition for the ionization of water $K_w = [H^+]\,[OH^-] = 1.0 \times 10^{-14}$ holds at	Listen the student's response and give feedback Give sample exercise and provide feedback

• write an expression for the percent ionization of weak acids or weak bases • calculate the percent dissociation of weak acids and bases • write the expression for the acid dissociation constant, K_a; • calculate K_a for an acid from the concentration of a given solution and its P^H; • Calculate $[H^+]$ and P^H of an acidic solution from given values of K_a and initial concentration of the solution. • Write the expression for the base dissociation constant, K_b • Calculate K_b for a base from the concentration of the basic solution and its pOH • Calculate the $[OH^-]$ and pOH of a basic solution from a given values of K_b and initial concentration of the solution	- pH and pOH - percent ionization - Ionization (dissociation) constant * Acid ionization constant, K_a * Base ionization constant, K_b	$25\ ^0C$. • They should calculate pH/pOH given from $[H^+]$ or $[OH^-]$and $[H^+]$ or $[OH^-]$ given from pH/pOH. • Students should explain that the strengths of acids and bases can be described in many ways. Some of the ways are: ○ H^+ and OH^- ions concentration ○ pH and pOH ○ Percent dissociation ○ K_a and K_b Here K_a and K_b are treated more • Students should do exercise to calculate K_a and K_b of an acid and a base from given solutions and their pH and pOH respectively.	Listen the student's response and give feedback Give sample exercise and provide feedback Observe the student's activity and give

• define common ion effect; • explain the importance of common ion effect; • define a buffer solution; • give some common examples buffer systems; • explain the action of buffer solution and it's importance in chemical processes • calculate the pH of a given buffer solution • demonstrate the buffer action of CH_3COOH/CH_3COONa;	**1.3 Common ion effect and Buffer Solution** *(9 periods)* • Common ion effect • Buffer solutions	• Students should be given a group activity to discuss on the concept common ion effect to see if they have understood the Le Chatelier's principle discussed in grade 11 Chemistry class • Students should demonstrate that buffer solutions have wide applications especially in biological systems • Students should describe that a buffer is a mixture/ solution that can be prepared by mixing a weak acid with one of its salts, or a weak base with one of its salts and discuss how buffer is useful in biological systems. • Students should demonstrate that a solution resists pH change in the presence of a buffer when a small amount of an acid or base is added, which otherwise would suffer pH change • Students should identify strong acids have very weak conjugate bases; strong bases have very weak conjugate acids	feedback Monitor the demonstration and give feedback Listen the student's response and give feedback Monitor the demonstration and give feedback Listen the student's response and give feedback Give sample exercise and provide feedback
• define hydrolysis;	**1.4 Hydrolysis of Salts** *(3 periods)* • Salts of weak acids and strong bases:		Monitor the discussion and give summary

• explain why a salt of weak acid and strong base gives a basic solution • explain why a salt of strong acid and weak base gives an acidic solution • explain why salts of weak acids and weak bases give acidic, basic or neutral solution	anion hydrolysis • Salts of strong acids and weak bases: cation hydrolysis • Salts of weak acids and week bases: cation and anion hydrolysis **1.5 Acid-base indicators and Titrations** *(6 periods)*	• Students should explain that solutions of salts contain two ions. The cation of the salt can potentially serve as an acid; the anion as a base • Students should identify whether a solution of a salt is acidic, basic, or neutral depends on the strengths of the acids and bases making the salt • Students should discuss hydrolysis of each type of salt. They may raise the following points: ○ **Salts of strong acids and strong bases**. Solutions of these salts are neutral. For Example, NaCl and KNO_3. ○ **Salts of weak acids and strong bases**. Solutions of theses salts are basic. Examples a $NaC_2H_3O_2$ and $NaNO_2$. ○ **Salts of weak acids and weak bases**. ○ Students should identify salts of strong acids and weak bases**.** Students should understand that solutions of theses salts are acidic because the cation of the weak base is a moderately strong acid. Examples are NH_4Cl and N_2H_5Cl. ○ Students should identify general case; the anion of the salt reacts as follows: $X^- + H_2O \leftrightarrow HX + OH^-$. Since a component of the salt is reacting with water, the phenomenon has come to be known as hydrolysis	Listen student's response and give feedback Observe the activity and give feedback
• define acid-base indicators • write some examples of acid-base indicators • suggest suitable indicator for a given	• Acid-base indicators • Equivalents of acids and bases - Number of equivalents - Normality	• Students should explain that acid-base indicators are organic molecules whose colors	Give sample exercise and provide feedback

acid-base titration • explain the equivalents of acids and bases • calculate the normality of a given acidic or basic solution • define acid-base titration	• Acid-base titrations	depend on the acidity or basicity of the solution • Students should perform an activity how to measure a pH or $[H^+]$ of a solution using pH meters by means of two electrodes immersed in a test solution • Students identify that acid-base indicators are organic molecules that indicate whether a solution is acidic, basic or neutral. • Students should identify that an acid-base indicator is a weak acid or weak base with its corresponding conjugate pair and the molecular form of the indicator, HIn, has one color and the ionic form In^-, has a different color. • Students should explain that the color that is observed in a solution of the indicator is controlled by the ratio of [Hin] to [In], which is determined in turn by the H^+ concentration in the solution and an indicator can be used to signal the completion of a reaction during a titration by changing color.	Listen student's response and give feedback Listen student's response and give feedback
• define end point • define equivalence point • distinguish between end point and equivalent point; • discuss the different types of titration curves	• The equivalent point and the end point • Acid-base titration curves - Titration of a strong acid with a strong base - Titration using a weak acid and a strong base - Titration of a weak base with a strong acid	• Students should explain that an equivalent of an acid is the mass of the acid that releases one mole of H^+ in solution. Likewise, an equivalent of a base is the mass of the base that produces one mole of OH^- or accepts one mole of H^+ • Students should explain that molarity and normality and see if they know that the difference lies in noticing the differences between equivalent mass and molecular mass • Students do exercise to calculate the normality of a given acidic or basic solution.	Listen student's response and give feedback Give sample exercise and provide feedback

		• Students should give examples like: A 0.1 M solutions of HCl in water and a 0.1 M solution acetic acid have pH's 1 and 2.9, respectively, that is they differ in acidity but the total concentration of acid is the same and each of these solutions neutralizes the same amount of NaOH solution • Students should identify that the equivalence point of a titration the pH is always 7. Students need to see that this is true only if the titration is between a strong acid and strong base and they could have to relate this to hydrolysis of anions or cations • Students should identify that acids are titrated to the point of neutralization by adding equivalent amount of a base. An indicator is employed to determine the end point. • Students should differentiate between equivalent point and end point of a titration • Students should describe that titration is an analytical method in which a solution, generally of known concentration, is added gradually from a burette to another solution where the solutes react. • Students should identify that acid base titration curves are drawn by plotting points corresponding to the pH of the solution and equivalents of the titrant added.	Give sample exercise and provide feedback Give sample exercise and provide feedback Listen student's response and give feedback Listen student's response and give feedback

Unit 2: Electrochemistry (*26 periods)*

Unit outcomes: *Students will be able to:*

- describe the fundamental concepts related to oxidation- reduction reaction;
- explain the application of redox reactions in production of new substances and energy;
- demonstrate an understanding of fundamental concepts related to the interconversion of chemical & electrical energy;
- distinguish between metallic conduction & electrolytic conduction;
- identify & describe the functioning of the components of electrolytic & galvanic cells;
- distinguish difference between electrolytic & galvanic cells;
- apply Faradays laws to solve problems associated with electrolysis experiment;
- measure through experimentation the mass of metal deposited by electroplating (e.g.: - copper from copper (II) sulphate), & apply Faraday's law to relate the mass of metal deposited to the amount of charge passed;
- predict the spontaneity of redox reactions & overall cell potentials by studying a table of half-cell reduction potentials;
- determine the emf of an electrochemical cell experimentally or from given data;
- explain the application of electrochemistry in our daily lives & in industry;
- explain corrosion as an electrochemical process, & describe corrosion- inhibiting techniques (e.g. painting, galvanizing, cathodic protection);
- describe examples of common galvanic cells & evaluate their environmental & social impact;

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Students will be able to: • define redox reaction • define oxidation in terms of electron transfer and change in oxidation number. • define reduction in terms of electron transfer and change in oxidation number. • describe the oxidizing and reducing agents • identify the species that are oxidized and reduced in a given redox reaction and determine the oxidizing and reducing agents	***2. Electrochemistry*** **2.1. Reduction-oxidation reactions** *(6 periods)* • Oxidation • Reduction	• Students should explain the importance /role of redox reaction in biological science especially its role to plant and animal physiology • Students should describe the rules to assign oxidation numbers and to define the terminologies like redox reaction, oxidation, reduction half-reaction, oxidizing agent and reducing agent • Students should be asked to identify the oxidized and reduced species and, the oxidizing and reducing agents • students should discuss the concept that an oxidizing agent itself reduced by taking example like the action of a bleaching agent on clothing in a washing machine	Listen student's response and give feedback Give sample exercise and provide feedback Monitor the discussion and provide summary
• explain metallic conductivity, electrolytic conductivity and electrolysis of molten electrolytes	**2.2 Electrolysis of Aqueous Solutions** *(7 periods)* • Electrolytic cell	• Students should discuss the metallic and electrolytic conductivities and electrolysis of molten electrolytes. • Students should discuss the processes that take place at the cathode and anode in an electrolytic cell • • Students should be asked to draw and label electrolytic cells. They should also show at which electrodes reduction	Monitor the discussion and provide summary Observe the student's activity d and provide feedback

		and oxidation reactions take place	Give sample exercise and provide feedback
• draw labeled diagrams of an electrolytic cell; • define preferential discharge	• Preferential discharge	• Students should identify that the electrode can discharge only one type of species in preference to the other at a time	
• explain factors that affect preferential discharge. • describe the effect of nature of the ions on the electrolysis of aqueous solutions of dil. H_2SO_4 and NaOH.		• Students should explain the process that electrons lost during oxidation half reaction are equal to electrons gained during reduction	Observe the activity of the students and give feedback
• describe the effect of concentration of the ions on the electrolysis of dilute and concentrated solutions of NaCl	• Electrolysis of some selected aqueous solutions	• Students should do the experiments on electrolysis of aqueous solutions and identify the effects of different factors on preferential discharge of ions. They should write also the anode, cathode and overall reactions name the product for each types of activities.	Give sample exercise and provide feedback
• describe the effects of types of electrodes on the electrolysis of $CuSO_4$ solution using Ni electrodes and Cu electrodes. • write electrode half reactions and overall reactions for the electrolysis of dil. H_2SO_4, NaOH, dil NaCl, conc. NaCl and $CuSO_4$ solutions • distinguish between molten electrolytes and		• Ask students to tell the difference between the electrolysis of molten electrolytic and aqueous electrolytic solutions.	

aqueous electrolytic solutions,			Listen student's response and provide feedback
• State Faraday's first law of electrolysis. • write the mathematical expression for the Faraday's first law of electrolysis, • do calculations related to Faraday's first law of electrolysis, • state Faraday's second law of electrolysis. • write the mathematical expression for the Faraday's second law of electrolysis. • do calculations related to Faraday's second law of electrolysis.	**2.3 Quantitative Aspects of Electrolysis** *(5 periods)* • Faraday's First Law of Electrolysis • Faraday's Second Law of Electrolysis	• Students should describe that electrolytic reactions are no exception to the general quantitative relationship of the amount of energy involved and the amount of chemical produced. • Students should be asked to write the formula of the two Faraday's laws of electrolysis. • Students to be asked to explain the Quantitative and qualitative significance of the of the two laws of Faraday by doing qualitative and quantitative problems • Students should be asked to practice calculations involving Faraday's laws of electrolysis as class work and assignment.	Give sample exercise and provide feedback Listen student's response and provide feedback
• mention industrial applications of electrochemistry, • explain electroplating and electro refining, • demonstrate copper refining, • explain how electrolysis is used in the production of some metals, nonmetals	**2.4 Industrial Application of Electrolysis (3 period)** • Electroplating and Electro refining • Extraction of metals • Manufacturer of Non-metals and some compounds	• Students should be asked to list down some of the applications of electrolysis in class. They should also be asked to explain to class how they are related to electrolysis.	Observe the activity and provide feedback Monitor the discussion and provide summary

and compounds,		• students should conduct simple experiment that show refining of copper	Give sample exercise and provide feedback
		• Students should discuss about electroplating and they should identify which electrode is the metal to be plated and the vice versa	
	2.5 Voltaic Cells *(5 periods)*	• They also should be asked to discuss how and which elements are extracted from their ores only through electrolysis.	Give sample exercise and provide feedback
• define voltaic cell and salt bridge	• Construction of Zn – Cu voltaic cell • Cell diagram (Notation for Voltaic cell)		
• draw and label Zn – Cu voltaic cell, • define electrode potential and cell potential, • construct Zn – Cu voltaic cell	• Electromotive Force • Measuring standard electrode potentials	• Students should identify that voltaic cells have important roles to play in society • Students should also be asked to write chemical equations for the reactions they take place in voltaic cell • Students should identify the various components of the voltaic cells and to draw diagrams of the various types of voltaic cells	Observe student's activity and provide feedback
• measure the cell potential of Zn – Cu cell using voltmeter			Give sample exercise and provide feedback
• explain how standard electrode potential is measured • describe the reactivity of a metal from its position in the activity series or electro motive series		• Students should construct a simple galvanic cell (Daniel's cell). They should identify the parts and measure the cell potential. • Students should measure potentials of half-cell using standard half-cells Finally, students can make their own EMF of given elements.	Observe student's activity and provide feedback
• calculate cell potential	• Calculation of cell potential		Listen student's response and provide

• decide whether a given redox reaction is spontaneous or not. • explain the effect of concentration on cell potential • Mention the different types of voltaic cells • give examples of each type of voltaic cell • describe how Hydrogen-Oxygen Fuel cell operates • distinguish between primary and secondary cells • identify the cathode, anode, and the electrolyte of a given voltaic cell, • compare and contrast electrolytic and voltaic cells • explain metallic corrosion in terms of redox reaction • explain the negative effects of corrosion, • explain the different methods of prevention of corrosion	• Dependence of emf on concentration • Types of voltaic cells, • Corrosion of metals	• Students should do exercise for calculating the cell potential and decide the spontaneity of the reactions • Students should be asked to collect and bring used and disposed batteries and asked to identify their types • Students should describe how hydrogen-oxygen fuel cell operates. • Students should tell the differences between primary, secondary and fuel cells. • Students should design and do experiments that will enable them to identify the factors responsible for corrosion of metals. Can the students see that this is a spontaneous reaction? Would we have to worry if it was a non-spontaneous reaction? • Students should discuss on the different methods of prevention of corrosion	feedback Observe student's activity and provide feedback Monitor the discussion and provide feedback

Unit 3: Industrial Chemistry (31 periods)

Unit outcomes: Students will be able to:

- list the renewable and non-renewable natural resources and appreciate their Importance to industry as raw materials
- describe the relationship between natural resources and industry
- list some chemical and related industries in Ethiopia
- list some important chemicals used for the manufacture of valuable products
- explain the major steps in the industrial production of ammonia, nitric acid, sulphuric acid, sodium hydroxide, sodium carbonate and aluminum sulphate and di-ammonium phosphate and other Nitrogen fertilizers ; and
- list some important direct uses of NH_3,HNO_3, H_2SO_4,Na_2CO_3 and their uses as raw material in production of other products
- list some important uses of NH_3,HNO_3, H_2SO_4,and Na_2CO_3 as raw material in production of other products.
- list some important uses of DAP, $(NH4)_2HPO_4$, nitrogen fertilizers, insecticides and Herbicides
- Produces insecticides from locally available material
- describe the uses of the common insecticides and pesticides that are manufactured in chemical industries
- discuss the important steps in the production of glass, ceramics, cement, sugar and paper and pulp
- describe the important steps in the production of soaps and detergent, and beverage
- Produce soaps in small scale from the available resources
- Describe the tanning process
- Apply local methods of tanning
- Use local methods of food preservation

Competencies	*Contents*	*Suggested Activities*	*Assessment*
Students will be able to:	**3 Industrial Chemistry**		
• Discuss the role of industry for the society	**3.1 Introduction** 2 period	✓ Students should discuss in group the role of chemical industries for the society	Monitor the group discussion and provide summary
•Define chemical industry		✓ Students should define industry and describe the general characteristics of Industries	
•Describe the application of minerals in industry		✓ Students should discuss in group and describe the general characteristics of chemical industries	Monitor the group discussion and provide summary
•List general characteristics of chemical industries		✓ Students Could list some common industries in Ethiopia	
•Define industry			Give exercise and provide feedback
•List some industries in Ethiopia			
•Describe the general characteristics of industries			
	3.2 Natural Resource and Industry (2 periods)		
• List natural resources • Classify natural resources as renewable and non-renewable • Classified manufacturing industries based on the raw material they utilize	• Natural resources • Renewable natural resources • Non-renewable natural resources • Classification of	✓ Students should have to list the available natural resources ✓ Students should classify the natural resources as renewable and non-renewable ✓ Students should classify the manufacturing industries based on the raw material they utilize	Listen student's response and provide feedback

	manufacturing industries based on the raw materials they utilize **3.3 production of valuable products (13 periods)**		
• Discuss the uses manufacturing valuable products/chemicals for the manufacturing of other products • Outline the production steps of valuable products like Ammonia, Nitric acid and sulphuric acid	• Production of Ammonia (NH_3)-Haber process • Nitric acid Manufacturing process (Ostwald process) • Sulphuric acid manufacturing process (contact process)	✓ Students should discuss in group of 4 or 5 about the uses of manufacturing valuable chemicals for the production of other products ✓ Students should draw schematic diagrams that shown the steps of production of Ammonia, Nitric acid and sulphuric acid	Monitor the group discussion and provide summary Help the students how they can draw the schematic diagram that shown the production steps
• Describe the condition in which the production of Ammonia, nitric acid and sulphuric acid increases		✓ Students should discuss and describe the condition in which how the production of Ammonia, nitric acid and sulphuric acid increases	Monitor the group discussion and provide summary
• Discuss the uses of DAP$(NH_4)_2HPO_4$, Nitrogen fertilizers, herbicides and insecticides in the agriculture sector • Produces insecticides from local available resources	• Diammonium monohydrogen phosphate (DAP,$(NH_4)_2HPO_4$ • Nitrogen Based fertilizers • Some common pesticides and herbicides	✓ Students should discuss the uses of DAP$(NH_4)_2HPO_4$, Nitrogen fertilizers, herbicides and insecticides in the agriculture sector ✓ Students should prepare insecticides from local available material (Neam leaf)	Monitor the group discussion and provide summary Facilitate and motivate students to prepare

			insecticides from Neam Leaf
• Describe the production steps of valuable products like sodium hydroxide and sodium carbonate	• Manufacturing of Sodium Carbonate (Solvay process) • Manufacturing of Sodium hydroxide	• Students should discuss and describe the steps present in production of sodium hydroxide and sodium carbonate	Monitor the group discussion and provide summary
	3.4 Some Manufacturing Industries in Ethiopia products (14 periods)		
• List the raw material that used in the manufacture of glass	• Glass manufacturing	• students should have to list the raw materials for the manufacture of glass	Listen student's response and provide feedback
• Outline the important steps in glass production		•Students should discuss in group and describe the process of manufacture of glass	Monitor the group discussion and provide summary
• Differentiate ordinary glass from the other		•students identify ordinary glass from Borosilicate glasses, such as Pyrex	Give exercise and check students response
• Describe the important steps in ceramics production	• Manufacturing of Ceramics	• Students should describe the process takes place in manufacture of ceramics	Listen student's response and provide feedback
• Draw schematic diagram and describe the important steps that shown cement production	• Cement production	• Students should draw schematic diagram and describe the important steps that shown cement production	Follow up students drawing and listen student's response and provide feedback
• Outline the important		•Students should give a brief description of the production of	

steps in sugar production	• Sugar production	sugar including: ✓ Sugar cane as the raw material ✓ How the sugar is extracted from the sugar cane ✓ Separation of sugar solution from remaining organic plant material ✓ removal of water to leave granulated sugar	Listen student's response and provide feedback
• Describe the important steps to be followed in paper and pulp manufacturing	• Paper and pulp	• students should describe the important steps to be followed in paper and pulp manufacturing	Listen student's response and provide feedback
• Explain how tanning is carried out • Describe the application of chemical preservation of skin and hide • Describe how tanning carried out using local available material	• Tannery • Tannery processing and production	•Students should give a brief description of the manufacture of leather including: ✓ How Tanning is carried out ✓ How Tannin alters the protein structure of the skin ✓ Why leather cannot turn back to skin? • Students should organize a report that describe how Tanning is carried out using local available material	Listen student's response and provide feedback
• Mention some uses of skin and hide •		• Students list common uses of skin and hide	Listen students report and give feedback
• Explain the process of food packing and preservation	• Food processing and preservative • Food processing and preservation	• Students should discuss the different methods of processing and preserving foods. These could include: traditional locally available methods e.g. ✓ Salting &Pickling ✓ Sugaring ✓ Smoking & Drying ✓ Canning & the modern methods e.g. ✓ Freezing, Freeze drying & Vacuum packing	Listen student's response and provide feedback
• Compile and Present a report in a class after visiting a nearby food processing factory		•Students should visit and compile report by vising the traditional and modern methods of food preservation methods that commonly used in Ethiopia • students should describe the important steps to be	Listen student's

• Discuss and describe how alcoholic beverages are produced • Compile and Present a report in a class after collecting information from the community about local alcoholic beverage preparation • List and describe the process how soaps and detergents are produced • Students perform experiments in laboratory to prepare soap • Compile and Present a report in a class after visiting a nearby cottage industry of soap	• Production of Alcoholic beverages • Local alcoholic beverages • Preparation of local alcoholic beverages (Areki or Katicala) • Soaps and detergents • Soaps • Dry detergent	followed during the preparation of alcoholic beverages • Students should organize a report that describe how local alcoholic beverages like Areki, Tella and Bordie is prepared by the community • students should describe the important steps to be followed during the production of soap and detergent • students should arrange the setup and perform the experiment to prepare soap in laboratory • Students should organize a report that describe how soap is produced in cottage industry	presentation and provide feedback Monitor the group discussion and give summary Listen student's response and provide feedback Observe the student's activity and provide feedback Listen student's presentation and provide feedback

Unit 4: Polymers (12 periods)

Unit outcomes: Students will be able to:

- define polymers
- realize that most of the materials around you may be polymers
- define, identify and classify monomers
- list a variety of synthetic polymers & natural polymers & explain their differences
- classify polymers into their types based on different criterion
- classify synthetic polymers as addition or condensation polymers & identify their monomers;
- classify synthetic polymers as addition or condensation polymers & identify their monomers
- describe the properties of the different types of polymers
- describe the monomers, properties & uses of plastics, rubbers, carbohydrates & proteins;
- list the applications of the different types of polymers
- define polymerization reactions
- list the different types of polymerization reactions
- describe the process of addition & condensation polymerization;

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Students will be able to: • define the terms monomer and polymer; • classify polymers into synthetic and natural polymers;	***4. Polymers*** **4.1 Polymerization (2 periods)** • Addition polymerization • Condensation polymerization	• Students should identify that macromolecules are made of smaller units (monomers) which could be made of identical monomers- homopolymers or different types of monomers- copolymers. • Students should be asked to list down examples of polymers from their surroundings and classify them as synthetic or natural polymers.	Give sample exercise and check students response Give sample exercise and check students response
• give examples of synthetic and natural polymers; • explain polymerization; • mention the two types of polymerizations; • explain how addition polymerization takes place; • explain how condensation polymerization takes place; • give examples of addition polymers; • tell the monomers of each of the given addition polymers • explain the common uses of addition polymers; • give examples of condensation polymers;	**4.2 Synthetic polymers(4 periods)** • Addition polymers - Polyethylene - Polypropylene - Polyvinyl chloride - Polymethyl metacrylate(Perspex) - Polystyrene - PolyTetraFlouroEthylene (PTFE) or Teflon • Condensation polymers	• Students should identify that polymerization could be affected either through: ○ Addition polymerization or ○ Condensation polymerization • Students should take reading assignment on the difference between addition and condensation polymerization that should be presented to the class, this will give opportunity for the student to applied organic chemistry is in everyday life both synthetically and naturally • Students should identify that the number of synthetic polymers is increasing rapidly in response to the needs of mankind • Students should be asked to discuss what problems are arising to surrounding/the environment with increasing of synthetic polymer and what should be taken as prevention mechanism	Give sample exercise and check students response Observe the activity and provide feedback Give sample exercise and check student's response Monitor the discussion and provide summary

• tell the monomers for the given condensation polymers; • explain the uses of condensation polymers: nylon, polyester, and bakelite; • describe thermoplastics and thermosetting polymers. • give examples of thermoplastics and thermosetting polymers;	- Nylon - Polyester (Dacron) - Bakelite • Thermoplastics and thermo setting polymers	• Students should be assigned to collect synthetic polymers which they think are useful or with serious drawbacks and they are asked to identify the polymers, the corresponding monomers and whether they are addition polymers or condensation polymers? • Students should identify that synthetic polymers are that they can design and produce materials with properties of their desire • Students should be asked to discuss what uses recycling have. What makes thermoplastic polymers recyclable whereas thermosetting ones are not? They should also ask to see the similarity with intermolecular forces in solids covered in grade 11 and thermoplastic and thermosetting polymers	Observe student's activity and provide feedback Give sample exercise and check students response Monitor the discussion and provide feedback
• describe natural rubber; • tell the monomer of natural rubber; • explain vulcanization • explain the use of natural rubber; • give three examples of synthetic rubbers; • explain uses the examples of synthetic rubbers; • compare and contrast synthetic and natural rubber; • define the term carbohydrate • describe mono saccharides; • draw the structure of monosaccharide,	**4.3 Natural polymers (6 periods)** • Rubber - Natural Rubber - Synthetic Rubber • Carbohydrates	• Students should be asked to list down as many natural polymers as they could find around them or even within them • Students should identify that the number of natural polymers is almost constant but every day new synthetic polymers are made? • Students should identify the monomers for the given synthetic and natural rubber polymers. • Students should discuss in group the role of sulfur in making rubber harder (vulcanization) • Students describe carbohydrates in detail about its components, characteristics, its classification and its biochemistry • Students should be asked to draw various structures of few monosaccharides including glucose	Give exercise and check students response Give exercise and check students response Monitor the discussion and provide feedback Listen student's response and provide feedback Observe student's

• give examples of mono saccharides • describe disaccharides; • draw the structure of disaccharides; • give examples of disaccharides; • describe poly saccharides; • draw structures of starch and cellulose; • explain the difference between starch, glycogen, and cellulose;	- Monosaccharide - Disaccharide - Polysaccharide	• Students should be asked to discuss whether there is any similarity between starch, cellulose and glycogen. Which ones can be used as energy sources by mammalian cells? Do they give the comparable amount of energy if combusted in a crucible? Do you see reasons for the differences?	activity and give feedback Observe student's activity and give feedback
• define the terms amino acid, peptide and protein; • describe the structure of amino acids; • explain how proteins are formed; list types of proteins;	• Proteins - Amino acid - Polypeptides	• Students should identify that proteins got their names from a similar Greek word meaning of primary importance and describe how proteins are composed • Students should discuss why proteins are called amino acids and about properties of amino acids that are important for polymerization. • Students should show similarity in the way amino acids are polymerized to form proteins with nylon. Why do amino acids and monomers of nylon have two functional groups? • Students should describe about the two types of nucleic acids, RNA and DNA.	Listen student's response and provide feedback Monitor the discussion and provide summary Observe the student's activity and provide feedback Listen students response and provide feedback

Unit 5: Introduction to Environmental Chemistry *(16 periods)*

- ***Unit outcomes:*** Students will be able to:
- Define terms related to environmental chemistry
- Explain environmental pollution
- Identify the three types of environmental pollution and list common pollutants of the environment;
- Discuss cause and effects of air ,water and soil pollution
- Describe pollutants of the environment
- Apply Pollution control mechanisms to reduce air, water and soil pollution
- Explain greenhouse gases and greenhouse effect.
- Discuss global warming and climate change
- Describe Green chemistry and cleaner production
- Apply principle of green chemistry and cleaner production

Competencies	***Contents***	***Suggested Activities***	***Assessment***
Students will be able to: • Explain the term environmental Chemistry • Describe components of the environment • Explain concepts related to environmental chemistry • Explain environmental pollution • List the common air pollutant and describe their effects on environment	***5.Introduction to Environmental Chemistry*** **5.1 Introduction (3 periods)** • Environmental chemistry • Components of the environment ✓ Natural cycle in the environment • Concepts related to the environment chemistry ✓ Pollutant ✓ Contaminate ✓ Dissolved oxygen, Chemical oxygen demand (COD), Biological oxygen demand (BOD) ,threshold limit value(TLV) **5.2 Environmental Pollution and Methods to reduce pollution (8 periods)** • Air pollution causes and effects ✓ Air pollutants ✓ SO_2, ✓ Oxide of nitrate, ✓ hydrocarbon and Ozone, ✓ Carbon monoxide,	• Students should discuss and explain environmental chemistry • Students should discuss and describe components of the environment • Students should discuss and describe the major natural cycles occurred in the environment • Students should discuss and explain components of the environment • Students should discuss and explain environmental pollution • Students should discuss and explain causes and effects of air pollution	Listen student's response and provide feedback Listen student's response and provide feedback Listen student's response and provide feedback

• Discuss air water and soil pollution • Describe the cause and effects air, water and soil pollution • Describe the mechanism of reduce air, water and soil/land pollution	✓ Chlorofluro carbon (CFCs, ✓ Excess Carbon dioxide and ✓ Heavy metals • Methods to reduce air pollution • Water pollution cause and effects • Methods of reducing water pollution • Land pollution • Methods of reducing land pollution • Waste segregation, recycling the wastes	• Students should list the common air pollutants and describe each • Students should identify the methods which is employed to reduce air pollution • Students should discuss and explain causes and effects of water pollution • Students should identify the methods which is employed to reduce water pollution • Students should discuss and explain causes and effects of land/soil pollution • Students should identify the methods which is employed to reduce land/soil pollution	Give exercise and provide feedback Give exercise and provide feedback Listen student's response and provide feedback Give exercise and provide feedback Give exercise and provide feedback
• Compile report how the community practices to reduce land/soil pollution and present to the class		• Students should organize a report about the common methods which is employed by the community to reduce land/soil pollution	Listen student's presentation and provide feedback
• Describe pollutants of the environment	• Pollutants of the environment ✓ Lead (Pb) ✓ Methane (CH_4) ✓ Plastic ✓ Mercury ✓ Fertilizers ✓ Volatile Organic compounds (VOCs)	• Students should discuss and describe pollutants of the environment	Monitor the group discussion and provide summary

• Discuss and explain global warming and climate change • Explain and describe Greenhouse effect and greenhouse gases • Demonstrate the greenhouse effect by constructing small scale greenhouse • Describe the principle of green chemistry and cleaner production • Explain atom economy • Apply the principle of green chemistry and cleaner production while doing experiments • Apply the concept of atom economy while doing experiments	✓ Organic dyes ✓ PCBs(polychlorinated biphenyl) ✓ Pesticides and herbicides ✓ Radioactive material **5.3 Global warming and Climate Change (2 periods)** • Global warming and climate change • Chemistry of greenhouse gases and their effects on climate change ✓ Greenhouse effect ✓ Composition of the atmosphere ✓ Contribution of greenhouse gases **5.4 Principle of green chemistry and cleaner production (3 periods)** • Principle of green chemistry • Cleaner production • Atom economy	• Students should discuss in group and explain global warming and climate change • Students should discuss and describe about the relationship between greenhouse gases and global warming • Students construct small scale greenhouse and demonstrate its effect • Students should discuss in group and describe about the principles of green chemistry and cleaner production • Students should discuss in group and explain what mean atom economy • Students should apply the principle of green chemistry and cleaner production while doing experiments in laboratory • Students should apply the concept of atom economy while doing experiments in laboratory	Monitor the group discussion and provide summary Follow up students activity and observe the demonstration Monitor the group discussion and provide summary Observe students while doing experiments whether they are apply the principle of atom economy and atom economy provide feedback